



MUNICIPALITY OF COLOMBO.

REPORT

XXIII

OF THE

MEDICAL OFFICER OF HEALTH,

FOR THE YEAR

1928.



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STATISTICAL SUMMARY.

| | | | | |
|--|-----|---------------|-----|-----------------|
| Mean temperature | ... | ... | ... | 80·8° F. |
| Rainfall | ... | ... | ... | 98·81 inches. |
| Average rainfall for the last 21 years | ... | ... | ... | 87·12 inches. |
| Area within Municipal Council's limits, exclusive of lake. | | | | 8,282 acres. |
| Population by Census of 1921 | ... | ... | ... | 244,163 |
| Estimated population as at July 1, 1928 | | | ... | 264,715 |
| Average density per acre | ... | ... | ... | 32·0 |
| Number of live births registered | ... | ... | ... | 9,486 |
| Birth-rate per 1,000 of estimated population | | | ... | 35·8* |
| Number of deaths of infants | ... | ... | ... | 1,714 |
| Infant mortality rate per 1,000 births | ... | ... | ... | 181 |
| Percentage of infant deaths to total mortality | | | ... | 21·5 |
| Stillbirths | ... | ... | ... | 693 |
| Number of deaths | ... | ... | ... | 7,989 |
| Crude death-rate per 1,000 of estimated population | | | ... | 30·2* |
| Corrected death-rate per 1,000 of estimated population | | | ... | 24·4* |
| Pneumonia | ... | No. of deaths | ... | 1,184 |
| | | Death-rate | ... | 4·47 per 1,000* |
| Phthisis | ... | No. of deaths | ... | 597 |
| | | Death-rate | ... | 2·26 per 1,000* |
| Enteric fever | ... | No. of deaths | ... | 140 |
| | | Death-rate | ... | 0·53 per 1,000* |
| Plague | ... | No. of deaths | ... | 37† |
| | | Death-rate | ... | 0·14 per 1,000* |
| Diarrhœa and enteritis. | | No. of deaths | ... | 572 |
| | | Death-rate | ... | 2·16 per 1,000* |

* The birth-and the death-rates given here are only for purposes of comparison with those of previous years, *vide* Section II.

† Inclusive of deaths of Colombo cases sent to the Infectious Diseases Hospital, which is beyond Municipal limits.

REPORT OF THE MEDICAL OFFICER OF HEALTH FOR 1928.

INTRODUCTION.

I HAVE the honour to submit the Administration Report of the Public Health Department for the year 1928.

Dr. C. V. Aserappa, the Medical Officer of Health, having gone away on a well-earned holiday, I assumed duties as Acting Medical Officer of Health on August 27, 1928.

That the figures obtained at the last census taken in 1921, after the war, were far from correct owing to various factors, *e.g.*, emigration, immigration, depression in trade, &c., has been brought to my notice, and consequently I have been compelled to eliminate certain statements giving figures depending on an estimated population calculated from an original number regarded as erroneous. Hence a good many of the rates have been left uncalculated and the figures only have been given. Nevertheless, such rates have been inserted in the statistical summary merely for purposes of comparison with those of the few preceding years.

Generally the same style has been adopted as in previous reports to facilitate more detailed study of the progress of the work of this department. An endeavour has been made to give a schematic representation of the staff of the Public Health Department and their duties so that an idea may be obtained as to the nature of the duties involved.

Taking everything into consideration the health of the population of Colombo during 1928 may be regarded as satisfactory. The corrected death-rate for the year was 24·4 as against 22·7 for the previous year, while on the other hand the birth-rate per 1,000 of the estimated population was 35·8 as against 32·4. This is the highest recorded birth-rate in the City.

The infant mortality rate was 181 per 1,000 births as against 187 for the previous year. It is indeed gratifying to be able to state that the year which showed the highest birth-rate also showed the lowest infant mortality rate on record. However, it is not forgotten that an infant mortality rate of 181 is still quite unsatisfactory, and the opening of the War Memorial Child Welfare Centre has given a great impetus towards more zealous work in this direction.

Infectious diseases :—Chickenpox and measles assumed an epidemic character during the year with the result that a far larger number of cases was reported during 1928 than in 1927, while the variation in numbers of the other infectious diseases was not marked.

With regard to those infectious diseases of a more serious nature, enteric fever showed an increase of 26 cases, while there were only 40 cases of plague, this being the second lowest on record. Ten cases of smallpox were reported during the year, the original case being in the person of an immigrant from India who came here in search of employment. The other nine cases were infected either directly or indirectly from this. (*Vide* Section X.)

Since the quarantine regulations are what they are such visitations are not unexpected, and the Public Health Department must for ever be on the alert.

Only one case of cholera was reported in the City.

A good deal of attention was paid during the year to our very insanitary housing conditions and a fair number of premises were improved.

It has long been realized that pneumonia and tuberculosis account for a large number of deaths. Both these diseases occur to a large extent among the dwellers in the slums, where in the case of pneumonia, apart from other causes, protection from rain and dampness is very inadequate, and in the case of tuberculosis overcrowding reaches its utmost limits. (*Vide* Section XXXIV.)

On the other hand, no opportunity has been missed in getting latrines of the dry-earth type connected to the sewer whenever possible. In a tropical climate, where enteric fever has been endemic for a long period of time resulting in the inevitable carrier and where the fly has all the amenities to breed in very large numbers, connection of every dry-earth latrine to a sewer must undoubtedly be one of the most effective measures against enteric fever. If house owners can only realize what this means they will have no hesitation in getting such premises connected to the sewer with the least possible delay. Apart from the fact that the money spent on such undertakings is in itself a profitable investment, it is a duty they owe to themselves and the community.

I am happy to be able to state that the work of every member of the staff—professional, clerical, or technical—has been consistently good and their loyalty unswerving, and this I record with grateful appreciation, for it has made my duties in administering the department as Acting Medical Officer of Health a pleasure rather than a task.

I wish to make special mention of the work of the clerical staff, and in this connection it is a pleasure to state that the rank of Muhandiram was conferred on Mr. J. C. Dewendre, the Head Clerk of this department, in recognition of his valuable and loyal services to the Council and the public.

Finally, the two Assistant Medical Officers of Health have given me invaluable assistance, since most of the routine and field work has been done by them ungrudgingly, efficiently, and uncommonly well. I am greatly indebted to them.

Part I.—Vital Statistics.

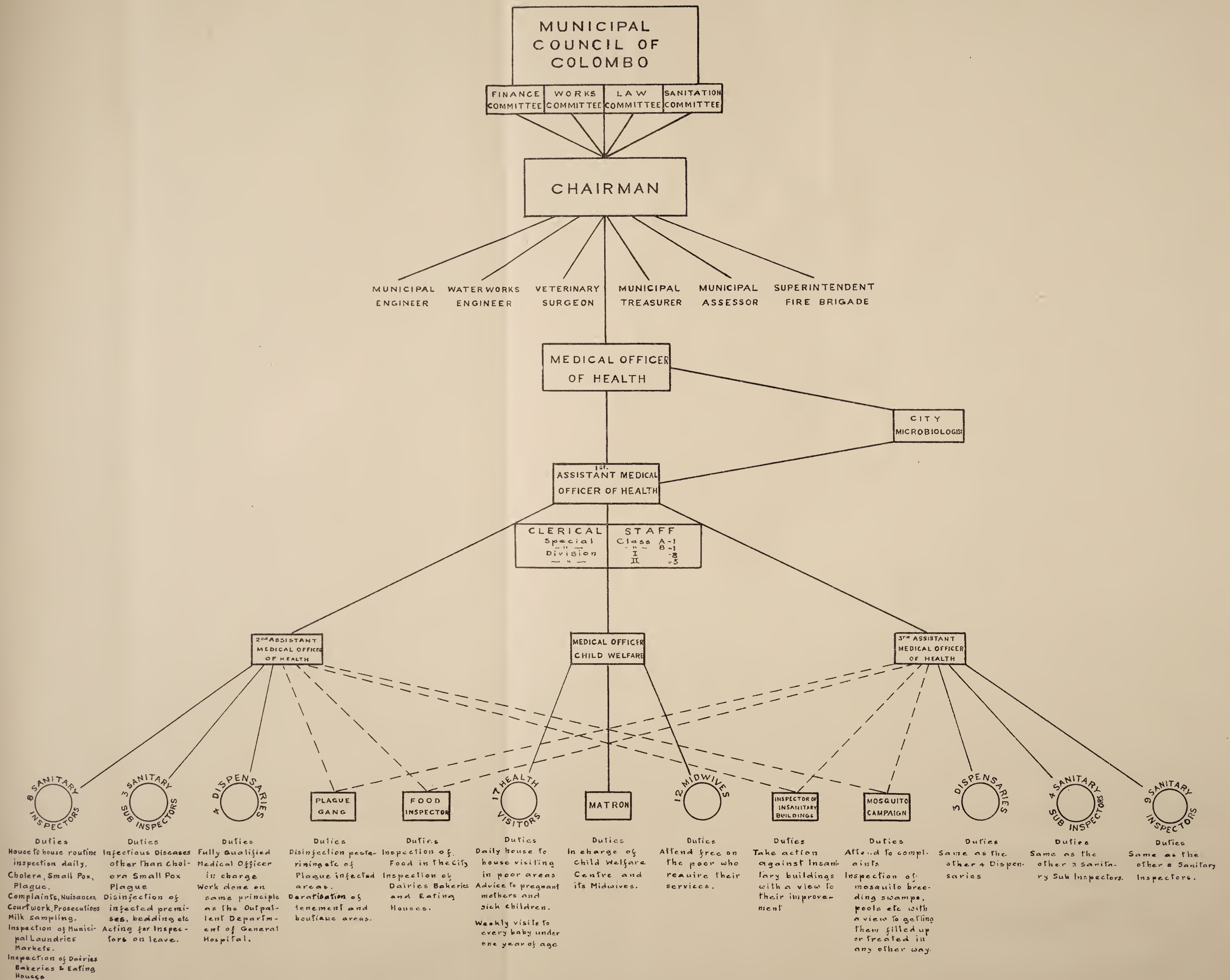
I.—METEOROLOGY.

Temperature.—The mean temperature for the year was 80·8° as against 81·0° for 1927 and 80·1° the average mean for the last 21 years. The minimum temperature was 78·6° in February and the maximum 82·8° in May.

Rainfall.—The total rainfall for the year was 98·81 inches as compared with 91·28 inches in 1927 and 87·12 the average for the last 21 years. The highest monthly record was 24·65 inches in October and the lowest 1·43 inches in September. The maximum rainfall recorded for any twenty-four hours was 3·40 inches on October 23.

Humidity.—The mean humidity for the year was 80 per cent. as against 81 per cent. for 1927. It ranged from 74 per cent. in September to 84 per cent. in November.

DIAGRAM N^o I



(1) *Statistics.*

(Supplied by the Superintendent of the Colombo Observatory.)

| (a) Average Monthly Mean Temperature at Colombo Observatory (Cinnamon Gardens). 21 Years, to 1928 inclusive. | | | (b) Monthly Mean Temperature at Colombo Observatory during 1928. | | | (c) Average Monthly Mean Pressure at Colombo Observatory (Cinnamon Gardens) reduced to Standard Gravity and Mean Sea Level. 17 Years, to 1928 inclusive. | | |
|---|-----|------|--|-----|------|---|-----|---------|
| | | ° F. | | | ° F. | | | Inches. |
| January | ... | 78'6 | January | ... | 79'4 | January | ... | 29'860 |
| February | ... | 79'0 | February | ... | 78'6 | February | ... | 29'854 |
| March | ... | 80'6 | March | ... | 81'0 | March | ... | 29'832 |
| April | ... | 81'8 | April | ... | 81'6 | April | ... | 29'798 |
| May | ... | 82'0 | May | ... | 82'8 | May | ... | 29'782 |
| June | ... | 81'1 | June | ... | 81'9 | June | ... | 29'782 |
| July | ... | 80'4 | July | ... | 81'3 | July | ... | 29'797 |
| August | ... | 80'4 | August | ... | 81'4 | August | ... | 29'813 |
| September | ... | 80'2 | September | ... | 82'5 | September | ... | 29'818 |
| October | ... | 79'4 | October | ... | 79'8 | October | ... | 29'830 |
| November | ... | 79'0 | November | ... | 79'8 | November | ... | 29'826 |
| December | ... | 78'6 | December | ... | 79'4 | December | ... | 29'842 |
| Year | ... | 80'1 | Year | ... | 80'8 | Year | ... | 29'820 |

| (d) Monthly Mean Pressure at Colombo Observatory during 1928 (reduced to Standard Gravity and Mean Sea Level). | | | (e) Average Monthly Rainfall at Colombo Observatory (Cinnamon Gardens). 21 Years, to 1928 inclusive. | | | (f) Monthly Rainfall at Colombo Observatory (Cinnamon Gardens) and Colombo Fort during 1928 (Observatory Gauge 2½ Feet and Fort 70 Feet above Mean Sea Level). | | | |
|--|-----|---------|---|-----|---------|--|------------------------------------|-----------------------------|--|
| | | Inches. | | | Inches. | | Colombo Observatory. Inches. | Colombo Fort. Inches. | |
| January | ... | 29'863 | January | ... | 3'69 | January | ... 6'27 | ... 5'13 | |
| February | ... | 29'868 | February | ... | 2'09 | February | ... 2'78 | ... 1'87 | |
| March | ... | 29'844 | March | ... | 4'73 | March | ... 3'65 | ... 5'23 | |
| April | ... | 29'788 | April | ... | 8'18 | April | ... 8'99 | ... 10'56 | |
| May | ... | 29'800 | May | ... | 13'56 | May | ... 7'92 | ... 5'70 | |
| June | ... | 29'770 | June | ... | 8'30 | June | ... 8'92 | ... 7'07 | |
| July | ... | 29'802 | July | ... | 6'48 | July | ... 5'65 | ... 5'88 | |
| August | ... | 29'850 | August | ... | 3'06 | August | ... 2'12 | ... 2'37 | |
| September | ... | 29'828 | September | ... | 6'28 | September | ... 1'44 | ... 0'91 | |
| October | ... | 29'838 | October | ... | 13'50 | October | ... 24'70 | ... 21'41 | |
| November | ... | 29'852 | November | ... | 11'78 | November | ... 17'59 | ... 10'26 | |
| December | ... | 29'829 | December | ... | 5'46 | December | ... 8'78 | ... 8'00 | |
| Year | ... | 29'828 | Year | ... | 87'12 | Year | ... 98'81 | ... 84'39 | |

| (g) Average Monthly Mean Humidity at Colombo Observatory (Cinnamon Gardens). 19 Years, to 1928 inclusive. | | | | (h) Monthly Mean Humidity at Colombo Observatory during 1928. | | | |
|--|-----|-----|-----------|---|-----|-----|-----------|
| | | | Per Cent. | | | | Per Cent. |
| January | ... | ... | 77 | January | ... | ... | 80 |
| February | ... | ... | 77 | February | ... | ... | 78 |
| March | ... | ... | 79 | March | ... | ... | 77 |
| April | ... | ... | 80 | April | ... | ... | 82 |
| May | ... | ... | 81 | May | ... | ... | 82 |
| June | ... | ... | 81 | June | ... | ... | 80 |
| July | ... | ... | 81 | July | ... | ... | 79 |
| August | ... | ... | 80 | August | ... | ... | 78 |
| September | ... | ... | 80 | September | ... | ... | 74 |
| October | ... | ... | 82 | October | ... | ... | 82 |
| November | ... | ... | 82 | November | ... | ... | 84 |
| December | ... | ... | 79 | December | ... | ... | 80 |
| Year | ... | ... | 80 | Year | ... | ... | 80 |

With reference to the rainfall at Fort, it should be noted that this gauge is not only higher above sea level than that at the Observatory but higher above adjacent ground level, and for this reason its readings might be expected to be less than those of a gauge at or near ground level. The difference between it and the readings at the Observatory is thus largely a matter of the difference in exposure of the two gauges. The Observatory gauge should be taken as the standard.

The humidity in tables (g) and (h) is the mean of the humidities derived from the maximum both dry and wet, and the minimum dry and wet.

It may be noticed that the average temperatures now given differ from those given up to 1927 inclusive by more than can be explained by the 1928 figures alone. This is because the use of large Stevenson screens has been adopted instead of sheds. Comparative readings were taken for several years between sheds and screens and the new averages are corrected for these differences and may be regarded as screen averages with which the current screen readings are comparable. The screen readings are undoubtedly more accurate than those in the sheds and the difference will generally be found to consist in the former being a trifle lower.

II.—POPULATION.

It has been pointed out that the census figures of 1921 are found to be abnormally low, due among other causes to emigration, depression in trade, and general after-effects of the war. The population estimated on 1921 Census for the middle of 1928 is 264,715, and this must under the circumstances be regarded as erroneous being much too low. The population based on the estimate prior to 1921 is about 342,000. This, in all probability, is nearer the true figure.

Therefore, as rates calculated on these estimates can only be uncertain and misleading, they have been omitted from this report, but with the exception of the "birth rate" and the "crude" and "corrected" death-rates given in Statements (2) and (3) and Statements (6) and (7) respectively.

The next census will be taken in 1931, and it is hoped that from that year onwards all the rates will be given as has hitherto been done.

III.—BIRTHS.

The number of births registered for the year under review is 9,486, representing a birth-rate of 35·8* per 1,000 of the estimated population, that of the previous year being 32·4.* The 1928 birth-rate is the highest on record, being just above that of 1921, which was 35·7* (*vide* Diagram II.). I have omitted the birth-rate of various races for the reasons given in Section II.

Stillbirths.—There were 693 stillbirths during the year, giving a rate of 68·0 per 1,000 births as against 67·2 for 1927. The highest as usual was among the Tamils (82·0 per 1,000), the two next in order being the Moors (73·3 per 1,000) and the Sinhalese (69·9 per 1,000) (*vide* Statement IV.).

The majority of the labourers are Tamils, Sinhalese, and Moors, and as such they are forced to live under deplorable housing conditions and in abject poverty, so much so that the poor pregnant mothers themselves have no alternative but to carry on, till the last moment, with their usual work, which in the majority of cases is of such a nature that women in their condition should never be called upon to do.

(2) *Births 1928, by Race.*

| Race. | No. of Births 1928. | Birth-rate per 1,000 Popu- lation, 1928. | Birth-rate per 1,000 Popu- lation, 1927. |
|---------------|------------------------|--|--|
| All Races ... | 9,486 | 35·8† | 32·4† |
| Europeans ... | 89 | | |
| Burghers ... | 600 | | |
| Sinhalese ... | 5,606 | | |
| Tamils ... | 1,254 | | |
| Moors ... | 1,391 | | |
| Malays ... | 347 | | |
| Others ... | 199 | | |

(3) *Births 1928, by Ward.*

| Ward. | Number of Births, 1928. | Birth-rate per 1,000 Population, 1928. | Birth-rate per 1,000 Population, 1927. |
|----------------------|-------------------------------|---|---|
| Colombo Town ... | 9,486 | 35·8† | 32·4† |
| Fort ... | 2 | | |
| Pettah ... | 30 | | |
| San Sebastian ... | 315 | | |
| St. Paul's ... | 590 | | |
| Kotahena ... | 603 | | |
| Mutwal ... | 644 | | |
| New Bazaar ... | 747 | | |
| Maradana North ... | 666 | | |
| Maradana South ... | 335 | | |
| Dematagoda ... | 482 | | |
| Slave Island ... | 605 | | |
| Kollupitiya ... | 276 | | |
| Cinnamon Gardens ... | 92 | | |
| Bambalapitiya ... | 144 | | |
| Timbirigasyaya ... | 251 | | |
| Wellawatta ... | 333 | | |
| Hospital ... | 3,371 | | |

(4) *Stillbirths in Colombo during the Year 1928, by Race.*

| Race. | No. of Stillbirths. | Rate per 1,000 Births (Live and Still). |
|---------------|------------------------|--|
| All Races ... | 693 | 68·0 |
| Europeans ... | 2 | 22·0 |
| Burghers ... | 28 | 44·6 |
| Sinhalese ... | 421 | 69·9 |
| Tamils ... | 112 | 82·0 |
| Moors ... | 110 | 73·3 |
| Malays ... | 10 | 28·0 |
| Others ... | 10 | 47·8 |

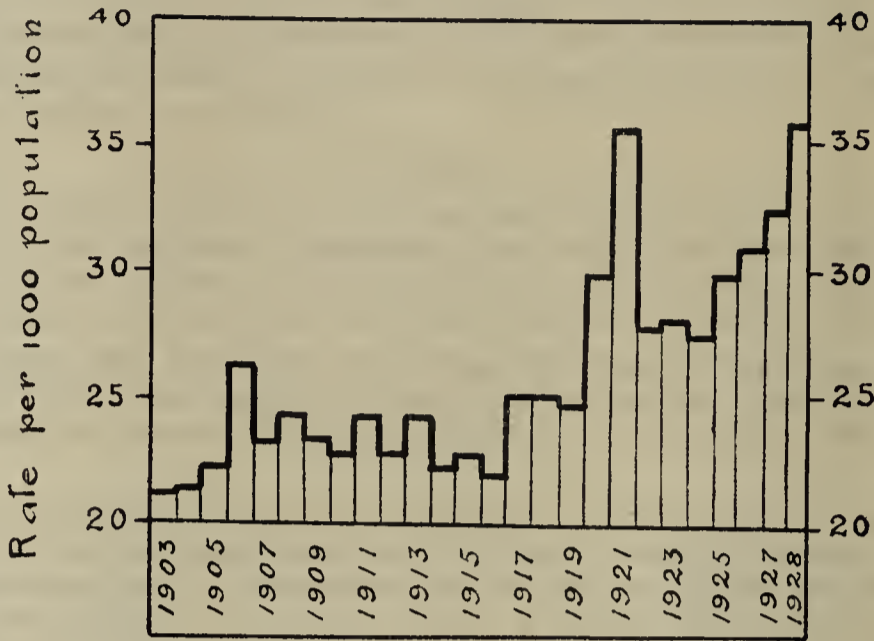
* Should be read with caution. *Vide* reasons given in Section II, under Population.

† The birth-rates given above are only provisional. The rates for the different Races and Wards have been omitted for reasons given in Section II.

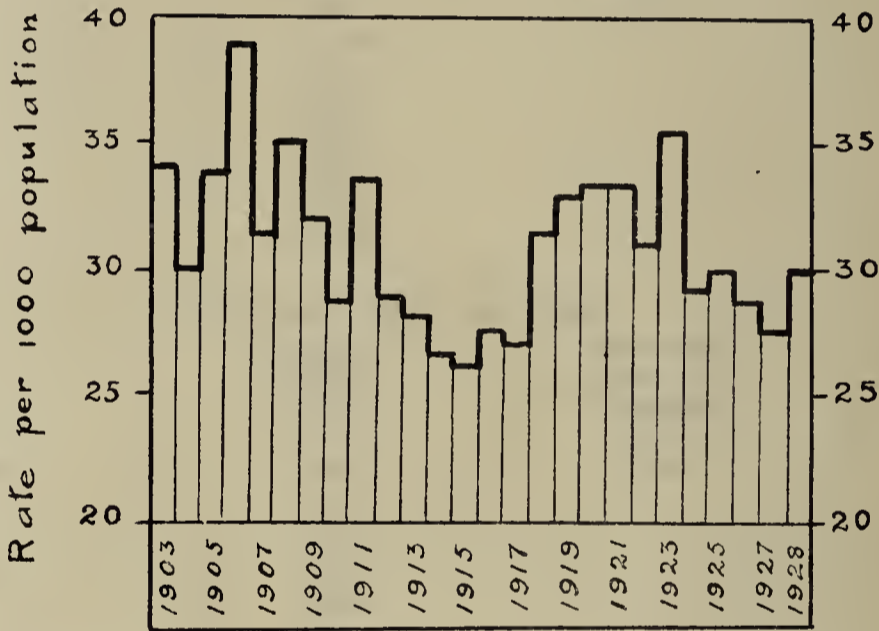
DIAGRAM N^o II

Note:- The Birth and Death Rates shown below are only provisional as they are calculated on the estimated population based on the 1921 Census figures, which were abnormally low.

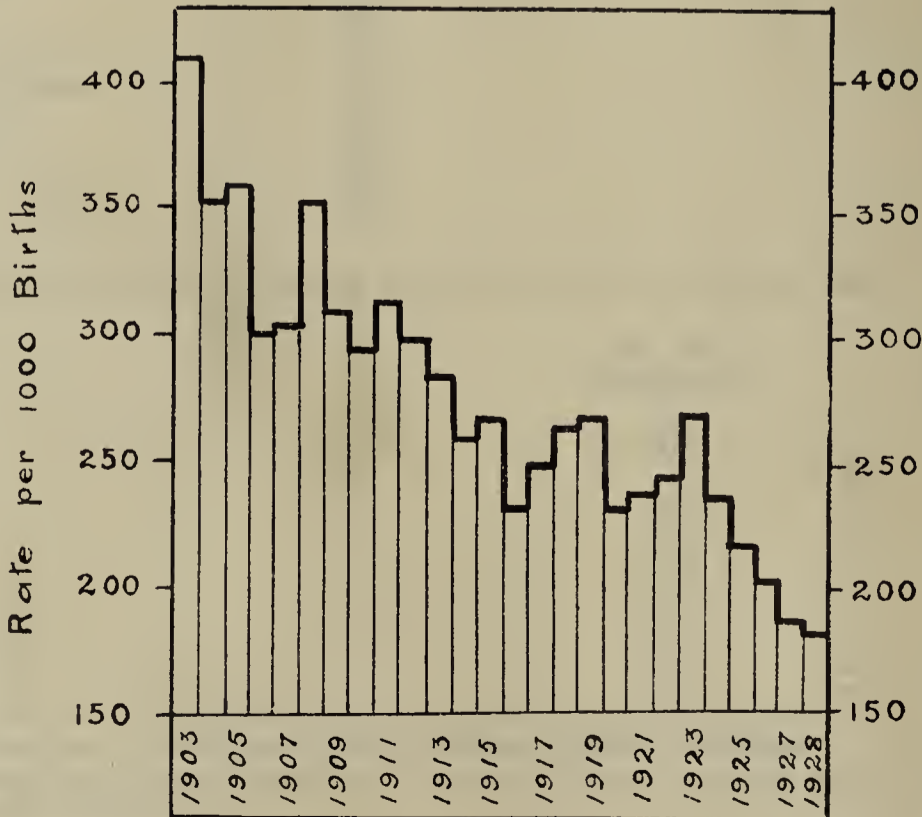
(a) BIRTH RATE 1903-1928



(b) CRUDE DEATH-RATE ALL AGES 1903-'28



(c) INFANT MORTALITY 1903-1928



(5) *Stillbirths during the Year 1928, by Ward.*

| Ward. | No. of Stillbirths. | Rate per 1,000 Births (Live and Still). | Ward. | No. of Stillbirths. | Rate per 1,000 Births (Live and Still). |
|--------------------|---------------------|---|----------------------|---------------------|---|
| Colombo Town ... | 693 | 68.0 | Maradana South ... | 10 | 29.0 |
| Fort ... | — | — | Dematagoda ... | 19 | 38.0 |
| Pettah ... | 1 | 32.3 | Slave Island ... | 31 | 48.7 |
| San Sebastian ... | 15 | 45.5 | Kollupitiya ... | 13 | 45.0 |
| St. Paul's ... | 49 | 76.7 | Cinnamon Gardens ... | 5 | 51.5 |
| Kotahena ... | 26 | 41.3 | Bambalapitiya ... | 11 | 71.0 |
| Mutwal ... | 24 | 36.0 | Timbirigasyaya ... | 9 | 34.6 |
| New Bazaar ... | 40 | 50.8 | Wellawatta ... | 16 | 45.8 |
| Maradana North ... | 29 | 41.7 | Hospitals ... | 395 | 104.9 |

IV.—DEATHS.

(a) *General Death-rate.**

The total number of deaths registered during the year was 7,989 as against 7,217 in 1927, showing an increase of 772. The number of deaths occurring in the hospitals also showed an increase of 346 as compared with that of 1927, while there was also an increase of 236 in the number of non-residents of Colombo dying at the Colombo hospitals.

The crude death-rate was 30.2 as against 27.6 for 1927. The corrected death-rate, corrected by the exclusion of the deaths of 1,695 non-residents in Colombo and including 175 deaths of Colombo residents that occurred in hospitals outside the City, was 24.4 as against 22.7 for 1927.

(b) and (c) *Ward and Racial Death-rates.*

These figures have been completely omitted from this report for the reasons given in Section II. as the error for estimated populations of each Ward must be still greater than that of the total estimated population of the City.

(6) *Deaths, 1928, by Ward.*

| Ward. | No. of Deaths, 1928. | Crude Death-rate, 1928. | Death-rate corrected for Deaths of Non-residents in Colombo Hospitals, 1928. | Death-rate corrected for Deaths in Colombo Hospitals, 1927. |
|----------------------|----------------------|-------------------------|--|---|
| Colombo Town ... | 7,989 | 30.2† | 23.8† | 22.0† |
| Fort ... | 19 | | | |
| Pettah ... | 52 | | | |
| San Sebastian ... | 235 | | | |
| St. Paul's ... | 492 | | | |
| Kotahena ... | 474 | | | |
| Mutwal ... | 612 | | | |
| New Bazaar ... | 585 | | | |
| Maradana North ... | 502 | | | |
| Maradana South ... | 289 | | | |
| Dematagoda ... | 396 | | | |
| Slave Island ... | 485 | | | |
| Kollupitiya ... | 171 | | | |
| Cinnamon Gardens ... | 48 | | | |
| Bambalapitiya ... | 85 | | | |
| Timbirigasyaya ... | 164 | | | |
| Wellawatta ... | 164 | | | |
| Hospitals ... | 3,216 | | | |

(7) *Deaths, 1928, by Race.*

| Race. | No. of Deaths, 1928. | Crude Death-rate, 1928. | Death-rate corrected for Deaths of Non-residents in Colombo Hospitals, 1928. | Death-rate corrected for Deaths of Colombo Residents in Hospitals outside Colombo, 1928. | Death-rate further corrected for Age and Sex Distribution. |
|---------------|----------------------|-------------------------|--|--|--|
| All Races ... | 7,989 | 30.2† | 23.8† | 24.4† | 28.5† |
| Europeans ... | 51 | | | | |
| Burghers ... | 325 | | | | |
| Sinhalese ... | 4,505 | | | | |
| Tamils ... | 1,470 | | | | |
| Moors ... | 1,142 | | | | |
| Malays ... | 231 | | | | |
| Others ... | 265 | | | | |

* These rates must be taken with caution for reasons given in Section II.

† The death-rates given above are only provisional. The rates for the different Wards have been omitted for reasons given in Section II.

NOTE.—The Colombo town crude death-rate includes 1,695 deaths of non-residents in Colombo hospitals.

(8) Births and Deaths, and the Infant Mortality, for each Ward of the Town of Colombo during the Year 1928.

| WARD. | BIRTHS. | | | | | | | DEATHS. | | | | | | | No. of Infant Deaths. | | | | | | |
|---------------------------|---------------|--------|----------|--------------|-----------|------------|---------|---------------|---------|---------|--------------|--------|----------|------------|-----------------------|-----------|------------|---------|--------|---------|---------|
| | Total Births. | | | Nationality. | | | | Total Deaths. | | | Nationality. | | | | | | | | | | |
| | Persons. | Males. | Females. | Europeans. | Burghers. | Sinhalese. | Tamils. | Moors. | Malays. | Others. | Persons. | Males. | Females. | Europeans. | | Burghers. | Sinhalese. | Tamils. | Moors. | Malays. | Others. |
| | | | | | | | | | | | | | | | | | | | | | |
| Colombo Town | 9,486 | 4,845 | 4,641 | 89 | 600 | 5,606 | 1,254 | 1,391 | 347 | 199 | 7,989 | 4,374 | 3,615 | 51 | 325 | 4,505 | 1,470 | 1,142 | 231 | 265 | 1,714 |
| Fort | 2 | 2 | — | 1 | 1 | — | — | — | — | — | 19 | 17 | 2 | 2 | 1 | 6 | 2 | 2 | — | 6 | — |
| Pettah | 30 | 14 | 16 | — | — | 11 | 9 | — | 5 | 5 | 52 | 43 | 9 | — | — | 11 | 17 | 16 | — | 8 | 7 |
| San Sebastian | 315 | 174 | 141 | — | 3 | 76 | 34 | 186 | 9 | 7 | 235 | 131 | 104 | — | 1 | 70 | 35 | 113 | 8 | 8 | 65 |
| St. Paul's | 590 | 308 | 282 | — | 11 | 133 | 246 | 161 | 9 | 30 | 492 | 266 | 226 | — | 5 | 93 | 222 | 136 | 2 | 34 | 129 |
| Kotahena | 603 | 299 | 304 | 2 | 45 | 337 | 138 | 61 | 15 | 5 | 474 | 227 | 247 | — | 28 | 247 | 135 | 54 | 6 | 4 | 144 |
| Mutwal | 644 | 323 | 321 | — | 31 | 458 | 69 | 61 | 10 | 15 | 612 | 289 | 323 | — | 17 | 440 | 86 | 48 | 9 | 12 | 145 |
| New Bazaar | 747 | 373 | 374 | — | 50 | 272 | 80 | 280 | 22 | 43 | 585 | 292 | 293 | — | 31 | 190 | 79 | 241 | 16 | 28 | 174 |
| Maradana North | 666 | 353 | 313 | — | 60 | 289 | 66 | 178 | 49 | 24 | 502 | 259 | 243 | 2 | 21 | 247 | 84 | 111 | 21 | 16 | 159 |
| Maradana South | 335 | 170 | 165 | — | 20 | 182 | 38 | 60 | 29 | 6 | 289 | 155 | 134 | 2 | 19 | 156 | 44 | 41 | 18 | 9 | 80 |
| Dematagoda | 482 | 254 | 228 | 1 | 29 | 259 | 56 | 93 | 36 | 8 | 396 | 228 | 168 | — | 29 | 244 | 40 | 63 | 17 | 3 | 95 |
| Slave Island | 605 | 308 | 297 | 2 | 47 | 180 | 89 | 136 | 119 | 32 | 485 | 263 | 222 | — | 19 | 160 | 81 | 108 | 97 | 20 | 142 |
| Kollupitiya | 276 | 141 | 135 | 5 | 17 | 166 | 40 | 32 | 12 | 4 | 171 | 88 | 83 | 7 | 14 | 87 | 28 | 25 | 6 | 4 | 33 |
| Cinnamon Gardens | 92 | 57 | 35 | 5 | 5 | 46 | 23 | 7 | 5 | 1 | 48 | 31 | 17 | 1 | 1 | 28 | 12 | 3 | 1 | 2 | 14 |
| Bambalapitiya | 144 | 78 | 66 | 6 | 23 | 82 | 21 | 8 | 1 | 3 | 85 | 44 | 41 | — | 13 | 47 | 16 | 8 | — | 1 | 15 |
| Timbirigasyaya | 251 | 123 | 128 | 46 | 5 | 164 | 28 | 4 | 1 | 3 | 164 | 90 | 74 | 15 | 5 | 115 | 21 | 7 | 1 | — | 36 |
| Wellawatta | 333 | 168 | 165 | 2 | 46 | 174 | 51 | 51 | 4 | 5 | 164 | 72 | 92 | — | 20 | 78 | 33 | 27 | 4 | 2 | 39 |
| Hospital (Town residents) | 3,371 | 1,700 | 1,671 | 19 | 207 | 2,777 | 266 | 73 | 21 | 8 | 1,416 | 845 | 571 | 8 | 75 | 754 | 369 | 118 | 20 | 72 | 437 |
| Hospital (Untraced) | | | | | | | | | | | | | | | | | | | | | |
| Hospital (Non-residents) | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | 1,695 | 960 | 735 | 12 | 23 | 1,476 | 136 | 16 | 1 | 31 | |

(5)

V.—PRINCIPAL CAUSES OF DEATHS.

Again pneumonia heads the list, having been responsible for 1,184 or 14·8 per cent. of the total deaths registered during the year under review. Next in order comes congenital debility with 636 or 8·0 per cent., pulmonary tuberculosis with 597 or 7·5 per cent., closely followed by diarrhœa and enteritis 572 or 7·2 per cent.

(9) *Principal Causes of Death during the Year 1928.*

| Cause of Death. | No. of Deaths. | |
|--|----------------|----------------------------|
| * Pulmonary Tuberculosis ... | 597 | } 641 Tubercular Diseases. |
| Tuberculosis of the Meninges and Central Nervous System ... | 2 | |
| Tuberculosis of the Intestines and Peritoneum. | 15 | |
| Tuberculosis of the Vertebral Column ... | 3 | |
| Tuberculosis of the Joints ... | — | |
| Tuberculosis of the Lymphatic System (mesenteric and retroperitoneal glands excepted). | 9 | |
| Disseminated Tuberculosis ... | 3 | |
| Tubercular Sinus ... | 12 | |
| Pneumonia (and Broncho-Pneumonia) ... | 1,184 | } 799 Total Diarrhœal. |
| Bronchitis ... | 179 | |
| Diarrhœa and Enteritis ... | 572 | |
| Dysentery ... | 227 | |
| * Enteric Fever ... | 139 | |
| Pyrexia ... | 58 | |
| Malaria ... | 174 | |
| * Plague ... | 23 | |
| Influenza ... | 435 | |
| Infantile Convulsions (under five years) ... | 274 | |
| Congenital Debility (under one year) ... | 636 | |

(10) *Certain Minor Causes of Death, 1928.*

| Cause of Death. | No. of Deaths. | Cause of Death. | No. of Deaths. |
|-------------------------------|----------------|----------------------------|----------------|
| Anchylostomiasis ... | 155 | * Diphtheria ... | 6 |
| Other Intestinal Parasites | 203 | Whooping Cough ... | 10 |
| Paralysis (cause unspecified) | 142 | Rabies ... | 20 |
| Rickets ... | 145 | * Smallpox ... | — |
| Cancer ... | 100 | * Cholera ... | — |
| Tetanus ... | 63 | Lethargic Encephalitis ... | 1 |
| * Measles ... | 2 | | |

(11) *Causes of Deaths registered in Colombo Town during the Year 1928.*

| Causes of Death. | Nationality. | | | | | | | |
|--|--------------|------------|-----------|------------|---------|--------|---------|---------|
| | All Races. | Europeans. | Burghers. | Sinhalese. | Tamils. | Moors. | Malays. | Others. |
| All Causes | 7,989 | 51 | 325 | 4,505 | 1,470 | 1,142 | 231 | 265 |
| I.—Epidemic, Endemic, and Infectious Diseases:— | | | | | | | | |
| 1.—Epidemic and Endemic Diseases | 1,024 | 5 | 33 | 522 | 211 | 172 | 28 | 53 |
| 2.—Infectious Diseases— | | | | | | | | |
| a. Tuberculous Diseases | 641 | — | 16 | 351 | 152 | 82 | 16 | 24 |
| b. Venereal Diseases... | 43 | — | 1 | 31 | 9 | 1 | 1 | — |
| c. Other Infectious Diseases | 126 | 1 | 3 | 75 | 27 | 13 | 2 | 5 |
| II.—General Diseases not in Class I. | | | | | | | | |
| 1.—Cancer and Malignant Diseases | 100 | 2 | 10 | 65 | 14 | 4 | — | 5 |
| 2.—Other General Diseases not in Class I. | 204 | 2 | 9 | 121 | 25 | 32 | 10 | 5 |
| III.—Diseases of the Nervous System and Organs of Special Sense | 605 | 7 | 40 | 341 | 99 | 86 | 25 | 7 |
| IV.—Diseases of the Circulatory System | 239 | 7 | 22 | 125 | 43 | 36 | 2 | 4 |
| V.—Diseases of the Respiratory System | 1,435 | 8 | 62 | 783 | 292 | 183 | 38 | 69 |
| VI.—Diseases of the Digestive System | 1,169 | 8 | 35 | 739 | 221 | 118 | 26 | 22 |
| VII.—Non-Venereal Diseases of the Genito-Urinary System and Annexa | 295 | 5 | 14 | 170 | 42 | 43 | 12 | 9 |
| VIII.—The Puerperal State | 207 | — | 7 | 131 | 26 | 29 | 11 | 3 |
| IX.—Diseases of the Skin and of the Cellular Tissue | 80 | — | 6 | 56 | 7 | 6 | 1 | 4 |
| X.—Diseases of the Bones and of the Organs of Locomotion | 1 | — | — | 1 | — | — | — | — |
| XI.—Malformations | 12 | — | 2 | 8 | — | 1 | — | 1 |
| XII.—Early Infancy | 802 | 1 | 33 | 440 | 136 | 148 | 21 | 23 |
| XIII.—Old Age | 495 | 1 | 20 | 245 | 70 | 122 | 27 | 10 |
| XIV.—External Causes— | | | | | | | | |
| 1.—Suicide | 27 | — | 2 | 13 | 9 | — | — | 3 |
| 2.—Homicide | 22 | — | — | 18 | 3 | 1 | — | — |
| 3.—Judicial Hanging or Execution | 27 | — | — | 22 | 2 | 2 | — | 1 |
| 4.—Accident and other External Violence. | 141 | 3 | 2 | 78 | 29 | 16 | 2 | 11 |
| XV.—Ill-defined Diseases | 294 | 1 | 8 | 170 | 53 | 47 | 9 | 6 |

* Those marked with an asterisk are notifiable infectious diseases.

N.B.—As Infectious Disease Hospital is now situated outside Colombo the deaths occurring there are not included in the above statement.

(11) Causes of Deaths, &c.—contd.

| Causes of Death. | Nationality. | | | | | | | |
|---|--------------|------------|-----------|------------|---------|--------|---------|---------|
| | All Races. | Europeans. | Burghers. | Sinhalese. | Tamils. | Moors. | Malays. | Others. |
| I.—EPIDEMIC, ENDEMIC, AND INFECTIOUS DISEASES. | | | | | | | | |
| 1.—Enteric Fever— | | | | | | | | |
| <i>a.</i> Typhoid Fever ... | 139 | — | 7 | 105 | 10 | 4 | 4 | 9 |
| <i>b.</i> Paratyphoid Fever ... | 1 | — | — | — | — | 1 | — | — |
| 2.—Typhus Fever ... | — | — | — | — | — | — | — | — |
| 3.—Relapsing Fever (<i>spirillum obermeieri</i>) ... | — | — | — | — | — | — | — | — |
| 4.—Malta Fever ... | — | — | — | — | — | — | — | — |
| 5.—Malaria— | | | | | | | | |
| <i>a.</i> Malarial Fever ... | 153 | 1 | 7 | 80 | 37 | 15 | 1 | 12 |
| <i>b.</i> Malarial Cachexia ... | 20 | 1 | — | 12 | 4 | 2 | — | 1 |
| <i>c.</i> Blackwater Fever ... | 1 | — | — | 1 | — | — | — | — |
| 6.—Smallpox— | | | | | | | | |
| <i>a.</i> Vaccinated ... | — | — | — | — | — | — | — | — |
| <i>b.</i> Unvaccinated ... | — | — | — | — | — | — | — | — |
| <i>c.</i> Vaccination doubtful ... | — | — | — | — | — | — | — | — |
| 7.—Measles ... | 2 | — | — | 2 | — | — | — | — |
| 8.—Scarlet Fever ... | — | — | — | — | — | — | — | — |
| 9.—Whooping Cough ... | 10 | — | 1 | — | 2 | 3 | 4 | — |
| 10.—Diphtheria ... | 6 | — | 1 | 5 | — | — | — | — |
| 11.—Influenza— | | | | | | | | |
| <i>a.</i> With pulmonary complications specified ... | 48 | — | 1 | 21 | 13 | 6 | 3 | 4 |
| <i>b.</i> Without pulmonary complications specified ... | 387 | — | 8 | 149 | 87 | 109 | 16 | 18 |
| 12.—Miliary Fever ... | — | — | — | — | — | — | — | — |
| 13.—Mumps ... | 2 | — | — | — | 2 | — | — | — |
| 14.—Asiatic Cholera ... | — | — | — | — | — | — | — | — |
| 15.—Cholera Nostras ... | — | — | — | — | — | — | — | — |
| 16.—Dysentery— | | | | | | | | |
| <i>a.</i> Amœbic ... | 13 | — | — | 12 | 1 | — | — | — |
| <i>b.</i> Bacillary ... | 14 | 1 | 1 | 10 | 1 | — | — | 1 |
| <i>c.</i> Other or unspecified ... | 200 | 2 | 6 | 118 | 46 | 23 | — | 5 |
| 17.—Plague— | | | | | | | | |
| <i>a.</i> Bubonic ... | 10 | — | — | 2 | 3 | 4 | — | 1 |
| <i>b.</i> Pneumonic ... | — | — | — | — | — | — | — | — |
| <i>c.</i> Septicæmic ... | 12 | — | — | 3 | 4 | 4 | — | 1 |
| <i>d.</i> Unspecified ... | 1 | — | — | — | — | — | — | 1 |
| 18.—Yellow Fever ... | — | — | — | — | — | — | — | — |
| 19.—Spirochetal Hæmorrhagic Jaundice ... | — | — | — | — | — | — | — | — |
| 20.—Leprosy ... | 1 | — | — | 1 | — | — | — | — |
| 21.—Erysipelas ... | 2 | — | — | 1 | 1 | — | — | — |
| 22.—Acute Anterior Poliomyelitis ... | 1 | — | — | — | — | 1 | — | — |
| 23.—Lethargic Encephalitis ... | 1 | — | 1 | — | — | — | — | — |
| 24.—Meningococcus Meningitis ... | — | — | — | — | — | — | — | — |
| 25.—Other Epidemic and Endemic Diseases— | | | | | | | | |
| <i>a.</i> Chickenpox ... | — | — | — | — | — | — | — | — |
| <i>b.</i> German Measles ... | — | — | — | — | — | — | — | — |
| <i>c.</i> Kala-azar ... | — | — | — | — | — | — | — | — |
| <i>d.</i> Others under this title ... | — | — | — | — | — | — | — | — |
| 26.—Glanders ... | — | — | — | — | — | — | — | — |
| 27.—Anthrax ... | 1 | — | — | 1 | — | — | — | — |
| 28.—Rabies (Hydrophobia) ... | 20 | — | — | 16 | 3 | 1 | — | — |
| 29.—Tetanus— | | | | | | | | |
| (1) Under one year ... | 11 | — | — | 3 | 4 | 4 | — | — |
| (2) One year and over ... | 52 | — | — | 27 | 15 | 5 | 1 | 4 |
| 30.—Mycoses— | | | | | | | | |
| <i>a.</i> Thrush ... | 9 | — | — | 4 | 2 | 2 | 1 | — |
| <i>b.</i> Other Mycoses ... | — | — | — | — | — | — | — | — |
| 31.—Tuberculosis of the Respiratory System— | | | | | | | | |
| <i>a.</i> Laryngeal Tuberculosis ... | 2 | — | — | — | 1 | — | 1 | — |
| <i>b.</i> Pulmonary Tuberculosis ... | 597 | — | 16 | 325 | 144 | 76 | 14 | 22 |
| 32.—Tuberculosis of the Meninges and Central Nervous System ... | 2 | — | — | — | 1 | — | — | 1 |
| 33.—Tuberculosis of the Intestines and Peritoneum. ... | 15 | — | — | 8 | 3 | 3 | 1 | — |
| 34.—Tuberculosis of the Vertebral Column ... | 3 | — | — | 2 | — | — | — | 1 |
| 35.—Tuberculosis of the Joints ... | — | — | — | — | — | — | — | — |
| 36.—Tuberculosis of other Organs— | | | | | | | | |
| <i>a.</i> Tuberculosis of the Skin and Subcutaneous Cellular Tissue ... | 1 | — | — | — | 1 | — | — | — |
| <i>b.</i> Tuberculosis of the Bones (vertebral column excepted) ... | 2 | — | — | 1 | — | 1 | — | — |
| <i>c.</i> Tuberculosis of the Lymphatic System (mesenteric and retroperitoneal glands excepted) ... | 9 | — | — | 7 | 1 | 1 | — | — |
| <i>d.</i> Tuberculosis of the Genito-Urinary System ... | 1 | — | — | 1 | — | — | — | — |
| <i>e.</i> Tuberculosis of Organs other than the above ... | 6 | — | — | 6 | — | — | — | — |
| 37.—Disseminated Tuberculosis— | | | | | | | | |
| <i>a.</i> Acute ... | — | — | — | — | — | 1 | — | — |
| <i>b.</i> Chronic or unspecified ... | 3 | — | — | 1 | 1 | 1 | — | — |
| 38.—Syphilis ... | 41 | — | 1 | 29 | 9 | 1 | 1 | — |
| 38 <i>a.</i> —Parangi (<i>Framboesia Tropicum</i> , Yaws) ... | — | — | — | — | — | — | — | — |
| 39.—Soft Chancre ... | — | — | — | — | — | — | — | — |
| 40.—Gonococcus Infection ... | 2 | — | — | 2 | — | — | — | — |
| 41.—Purulent Infection, Septicæmia ... | 31 | 1 | 3 | 23 | 3 | — | — | 1 |

(11) *Causes of Deaths, &c.*—contd.

| Causes of Death. | | Nationality. | | | | | | | | | | | | | |
|--|--|--------------|------------|-----------|------------|---------|--------|---------|---------|----|----|----|---|----|--|
| | | All Races. | Europeans. | Burghers. | Sinhalese. | Tamils. | Moors. | Malays. | Others. | | | | | | |
| 42.—Other Infectious Diseases— | | | | | | | | | | | | | | | |
| <i>a.</i> Vaccinia ... | | 1 | — | — | — | — | — | — | — | 1 | — | — | — | — | |
| <i>b.</i> Other diseases under this title ... | | 1 | — | — | — | — | 1 | — | — | — | — | — | — | — | |
| II.—GENERAL DISEASES NOT INCLUDED IN CLASS I. | | | | | | | | | | | | | | | |
| 43.—Cancer and other Malignant Tumours of the Buccal Cavity ... | | 22 | — | — | 3 | — | 14 | — | 3 | — | 1 | — | — | 1 | |
| 44.—Cancer and other Malignant Tumours of the Stomach, Liver ... | | 18 | — | 1 | — | 1 | 10 | — | 4 | — | 1 | — | — | 1 | |
| 45.—Cancer and other Malignant Tumours of the Peritoneum, Intestines, Rectum ... | | 10 | — | 1 | — | — | 8 | — | — | — | 1 | — | — | — | |
| 46.—Cancer and other Malignant Tumours of the Female Genital Organs ... | | 15 | — | — | 2 | — | 10 | — | 3 | — | — | — | — | — | |
| 47.—Cancer and other Malignant Tumours of the Breast ... | | 13 | — | — | 1 | — | 10 | — | 2 | — | — | — | — | — | |
| 48.—Cancer and other Malignant Tumours of the Skin ... | | 1 | — | — | — | — | 1 | — | — | — | — | — | — | — | |
| 49.—Cancer and other Malignant Tumours of other or unspecified Organs ... | | 21 | — | — | 3 | — | 12 | — | 2 | — | 1 | — | — | 3 | |
| 50.—Tumours not returned as Malignant (Brain and Female Genital Organs excepted) ... | | 5 | — | — | — | — | 2 | — | 2 | — | 1 | — | — | — | |
| 51.—Acute Rheumatic Fever ... | | 4 | — | — | 1 | — | 2 | — | — | — | 1 | — | — | — | |
| 52.—Chronic Rheumatism, Osteoarthritis, Gout ... | | 16 | — | — | — | — | 6 | — | 4 | — | 6 | — | — | — | |
| 53.—Scurvy ... | | — | — | — | — | — | — | — | — | — | — | — | — | — | |
| 54.—Pellagra ... | | — | — | — | — | — | — | — | — | — | — | — | — | — | |
| 55.—Beri-Beri ... | | 1 | — | — | — | — | — | — | — | — | — | — | — | 1 | |
| 56.—Rickets ... | | 45 | — | — | 2 | — | 19 | — | 1 | — | 12 | — | 9 | 2 | |
| 57.—Diabetes Mellitus ... | | 83 | — | — | 5 | — | 67 | — | 4 | — | 6 | — | 1 | — | |
| 58.—Anæmia, Chlorosis— | | | | | | | | | | | | | | | |
| <i>a.</i> Pernicious Anæmia ... | | 7 | — | — | — | — | 2 | — | 3 | — | 2 | — | — | — | |
| <i>b.</i> Other Anæmias and Chlorosis ... | | 19 | — | — | — | — | 7 | — | 7 | — | 4 | — | — | 1 | |
| 59.—Diseases of the Pituitary Gland ... | | — | — | — | — | — | — | — | — | — | — | — | — | — | |
| 60.—Diseases of the Thyroid Gland— | | | | | | | | | | | | | | | |
| <i>a.</i> Exophthalmic Goitre ... | | 1 | — | — | — | — | — | — | 1 | — | — | — | — | — | |
| <i>b.</i> Other diseases of the Thyroid Gland ... | | 2 | — | — | — | — | 2 | — | — | — | — | — | — | — | |
| 61.—Diseases of the Parathyroid Glands ... | | 1 | — | — | 1 | — | — | — | — | — | — | — | — | — | |
| 62.—Diseases of the Thymus Gland ... | | — | — | — | — | — | — | — | — | — | — | — | — | — | |
| 63.—Diseases of the Adrenale (Eddison's Disease) . | | — | — | — | — | — | — | — | — | — | — | — | — | — | |
| 64.—Diseases of the Spleen ... | | — | — | — | — | — | — | — | — | — | — | — | — | — | |
| 65.—Leukæmia and Hodgkin's Disease— | | | | | | | | | | | | | | | |
| <i>a.</i> Leukæmia ... | | 3 | — | — | — | — | 2 | — | 1 | — | — | — | — | — | |
| <i>b.</i> Hodgkin's Disease ... | | 2 | — | — | — | — | 2 | — | — | — | — | — | — | — | |
| 66.—Alcoholism (acute or chronic) ... | | 4 | — | 2 | — | — | — | — | 1 | — | — | — | — | 1 | |
| 67.—Chronic Poisoning by mineral substances— | | | | | | | | | | | | | | | |
| <i>a.</i> Chronic Lead Poisoning ... | | — | — | — | — | — | — | — | — | — | — | — | — | — | |
| <i>b.</i> Others under this title ... | | 2 | — | — | — | — | 2 | — | — | — | — | — | — | — | |
| 68.—Chronic Poisoning by organic substances ... | | — | — | — | — | — | — | — | — | — | — | — | — | — | |
| 69.—Other General Diseases ... | | 9 | — | — | — | — | 8 | — | 1 | — | — | — | — | — | |
| III.—DISEASES OF THE NERVOUS SYSTEM AND OF THE ORGANS OF SPECIAL SENSE. | | | | | | | | | | | | | | | |
| 70.—Encephalitis ... | | 3 | — | — | 1 | — | 2 | — | — | — | — | — | — | — | |
| 71.—Meningitis— | | | | | | | | | | | | | | | |
| <i>a.</i> Simple Meningitis ... | | 39 | — | 2 | — | 5 | — | 22 | — | 10 | — | — | — | — | |
| <i>b.</i> Non-epidemic Cerebro Spinal Meningitis ... | | 1 | — | — | — | — | — | — | — | — | 1 | — | — | — | |
| 72.—Tabes Dorsalis (Locomotor Ataxia) ... | | — | — | — | — | — | — | — | — | — | — | — | — | — | |
| 73.—Other Diseases of the Spinal Cord ... | | 4 | — | — | 1 | — | 3 | — | — | — | — | — | — | — | |
| 74.—Cerebral Hæmorrhage, Apoplexy— | | | | | | | | | | | | | | | |
| <i>a.</i> Cerebral Hæmorrhage ... | | 89 | — | — | 11 | — | 38 | — | 20 | — | 15 | — | 5 | — | |
| <i>b.</i> Cerebral Embolism and Thrombosis.. | | 21 | — | 1 | — | 3 | — | 15 | — | 1 | — | — | 1 | — | |
| 75.—Paralysis without specified cause— | | | | | | | | | | | | | | | |
| <i>a.</i> Hemiplegia ... | | 52 | — | 1 | — | 6 | — | 23 | — | 6 | — | 12 | — | 4 | |
| <i>b.</i> Other forms of Paralysis ... | | 90 | — | — | — | 5 | — | 71 | — | 5 | — | 6 | — | 3 | |
| 76.—General Paralysis of the Insane ... | | 1 | — | — | — | — | — | 1 | — | — | — | — | — | — | |
| 77.—Other forms of insanity ... | | 2 | — | — | — | — | — | — | 1 | — | — | — | 1 | — | |
| 78.—Epilepsy ... | | 10 | — | 2 | — | 1 | — | 4 | — | — | 3 | — | — | — | |
| 79.—Convulsions (non-puerperal ; 5 years and over) | | 11 | — | — | — | — | — | 7 | — | 2 | — | 1 | — | — | |
| 80.—Infantile Convulsions (under 5 years of age) . | | 274 | — | 1 | — | 7 | — | 151 | — | 52 | — | 48 | — | 10 | |
| 81.—Chorea ... | | — | — | — | — | — | — | — | — | — | — | — | — | — | |
| 82.—Neuralgia and Neuritis ... | | — | — | — | — | — | — | — | — | — | — | — | — | — | |
| 83.—Softening of the Brain ... | | — | — | — | — | — | — | — | — | — | — | — | — | — | |
| 84.—Other Diseases of the Nervous System ... | | 3 | — | — | — | — | — | 1 | — | 1 | — | — | — | 1 | |
| 85.—Diseases of the Eye and Annexa ... | | 1 | — | — | — | — | — | 1 | — | — | — | — | — | — | |
| 86.—Diseases of the Ear and of the Mastoid Process. | | — | — | — | — | — | — | — | — | — | — | — | — | — | |
| <i>a.</i> Diseases of the Ear ... | | 2 | — | — | — | — | — | 2 | — | — | — | — | — | — | |
| <i>b.</i> Diseases of the Mastoid Process ... | | 2 | — | — | — | — | — | — | 1 | — | — | — | — | 1 | |
| IV.—DISEASES OF THE CIRCULATORY SYSTEM. | | | | | | | | | | | | | | | |
| 87.—Pericarditis ... | | 7 | — | — | 1 | — | 3 | — | 2 | — | 1 | — | — | — | |
| 88.—Acute Endocarditis and Myocarditis ... | | 51 | — | 1 | — | 5 | — | 26 | — | 12 | — | 6 | — | 1 | |
| 89.—Angina Pectoris ... | | 12 | — | 1 | — | 3 | — | 2 | — | 2 | — | 2 | — | 1 | |
| 90.—Other Diseases of the Heart— | | | | | | | | | | | | | | | |
| <i>a.</i> Valvular Disease ... | | 49 | — | 1 | — | 2 | — | 32 | — | 3 | — | 11 | — | — | |
| <i>b.</i> Fatty Degeneration of Heart ... | | 9 | — | — | — | 1 | — | 3 | — | 4 | — | 1 | — | — | |
| <i>c.</i> Others under this title ... | | 69 | — | 3 | — | 4 | — | 36 | — | 11 | — | 13 | — | 1 | |

(11) *Causes of Deaths, &c.*—contd.

| Causes of Death. | All Races. | Nationality. | | | | | | |
|--|------------|--------------|-----------|------------|---------|--------|---------|---------|
| | | Europeans. | Burghers. | Sinhalese. | Tamils. | Moors. | Malays. | Others. |
| 91.—Diseases of the Arteries— | | | | | | | | |
| <i>a.</i> Aneurysm ... | 9 | — | 2 | 5 | 2 | — | — | — |
| <i>b.</i> Arteriosclerosis ... | 6 | 1 | — | 5 | — | — | — | — |
| <i>c.</i> Other Diseases of the Arteries ... | — | — | — | — | — | — | — | — |
| 92.—Embolism and Thrombosis (not Cerebral)... | 16 | — | 3 | 8 | 5 | — | — | — |
| 93.—Diseases of the Veins (Varices, Hæmorrhoids, Phlebitis, &c.) ... | 8 | — | 1 | 4 | — | 2 | — | 1 |
| 94.—Diseases of the Lymphatic System (Lymphangitis, &c.) ... | 2 | — | — | 1 | 1 | — | — | — |
| 95.—Hæmorrhage without stated cause ... | 1 | — | — | — | 1 | — | — | — |
| 96.—Other Diseases of the Circulatory System ... | — | — | — | — | — | — | — | — |
| V.—DISEASES OF THE RESPIRATORY SYSTEM. | | | | | | | | |
| 97.—Diseases of the Nasal Fossæ and their Annexæ— | | | | | | | | |
| <i>a.</i> Diseases of the Nose ... | — | — | — | — | — | — | — | — |
| <i>b.</i> Others under this title ... | 1 | — | — | 1 | — | — | — | — |
| 98.—Diseases of the Larynx ... | 4 | — | 1 | 3 | — | — | — | — |
| 99.—Bronchitis— | | | | | | | | |
| <i>a.</i> Acute ... | 37 | — | 1 | 18 | 7 | 7 | 3 | 1 |
| <i>b.</i> Chronic ... | 78 | 1 | 2 | 45 | 17 | 11 | 1 | 1 |
| <i>c.</i> Unspecified (under 5 years of age) ... | 51 | — | 4 | 29 | 7 | 6 | 3 | 2 |
| <i>d.</i> Unspecified (5 years and over) ... | 13 | — | 1 | 8 | 3 | — | — | 1 |
| 100.—Broncho-Pneumonia ... | 578 | 4 | 34 | 345 | 89 | 75 | 19 | 12 |
| 101.—Pneumonia ... | — | — | — | — | — | — | — | — |
| <i>a.</i> Lobar ... | 199 | 2 | 7 | 85 | 50 | 32 | 3 | 20 |
| <i>b.</i> Unspecified ... | 407 | 1 | 11 | 213 | 105 | 39 | 8 | 30 |
| 102.—Pleurisy— | | | | | | | | |
| <i>a.</i> Empyema ... | 10 | — | — | 7 | 2 | 1 | — | — |
| <i>b.</i> Other forms of Pleurisy ... | 13 | — | — | 9 | 1 | 2 | — | 1 |
| 103.—Congestion and Hemorrhagic Infarct of the Lung ... | 14 | — | 1 | 4 | 5 | 2 | 1 | 1 |
| 104.—Gangrene of the Lung ... | 4 | — | — | 4 | — | — | — | — |
| 105.—Asthma ... | 25 | — | — | 10 | 6 | 8 | — | — |
| 106.—Pulmonary Emphysema ... | — | — | — | — | — | — | — | — |
| 107.—Other Diseases of the Respiratory System— | | | | | | | | |
| <i>a.</i> Chronic Interstitial Pneumonia, including Occupational Diseases of the Lungs ... | — | — | — | — | — | — | — | — |
| <i>b.</i> Diseases of the Mediastinum ... | 1 | — | — | 1 | — | — | — | — |
| <i>c.</i> Other under this title ... | 1 | — | — | 1 | — | — | — | — |
| VI.—DISEASES OF THE DIGESTIVE SYSTEM. | | | | | | | | |
| 108.—Diseases of the Buccal Cavity and Annexæ... | 4 | — | — | 4 | — | — | — | — |
| 109.—Diseases of the Pharynx and Tonsils ... | — | — | — | — | — | — | — | — |
| <i>a.</i> Tonsillitis, Adenoid Vegetations ... | 1 | — | — | — | — | 1 | — | — |
| <i>b.</i> Other Diseases under this title ... | 1 | — | — | 1 | — | — | — | — |
| 110.—Diseases of the Oesophagus ... | 1 | — | — | 1 | — | — | — | — |
| 111.—Ulcer of the Stomach or Duodenum— | | | | | | | | |
| <i>a.</i> Ulcer of the Stomach ... | 3 | — | — | 1 | — | 1 | 1 | — |
| <i>b.</i> Ulcer of the Duodenum ... | 1 | — | — | — | 1 | — | — | — |
| 112.—Other Diseases of the Stomach ... | 25 | — | 2 | 19 | 1 | 2 | 1 | — |
| 113.—Diarrhœa and Enteritis (under 2 years of age) ... | 255 | — | 14 | 165 | 32 | 30 | 10 | 4 |
| 114.—Diarrhœa and Enteritis (2 years and over)... | 317 | — | 9 | 187 | 80 | 30 | 6 | 5 |
| 115.—Anchylostomiasis ... | 155 | — | 2 | 107 | 31 | 9 | — | 3 |
| 116.—Diseases due to other Intestinal Parasites— | | | | | | | | |
| <i>a.</i> Cestodes (Hydatids of the Liver excepted) ... | — | — | — | — | — | — | — | — |
| <i>b.</i> Trematodes ... | — | — | — | — | — | — | — | — |
| <i>c.</i> Nematodes (other than Anchylostoma) ... | 10 | — | — | 7 | 1 | — | 2 | — |
| <i>d.</i> Coccidia ... | — | — | — | — | — | — | — | — |
| <i>e.</i> Other parasites specified ... | 1 | 1 | — | — | — | — | — | — |
| <i>f.</i> Parasites not specified ... | 192 | — | 1 | 127 | 29 | 29 | 3 | 3 |
| 117.—Appendicitis and Typhlitis ... | 16 | 2 | 1 | 7 | 3 | 3 | — | — |
| 118.—Hernia, Intestinal Obstruction— | | | | | | | | |
| <i>a.</i> Hernia ... | 16 | — | 1 | 10 | 2 | 2 | 1 | — |
| <i>b.</i> Intestinal obstruction ... | 30 | — | — | 14 | 11 | 4 | 1 | — |
| 119.—Other Diseases of the Intestines— | | | | | | | | |
| <i>a.</i> Psilosis (Sprue or Ceylon Sore-mouth) ... | 7 | — | 1 | 3 | 2 | 1 | — | 1 |
| <i>b.</i> Others under this title ... | 14 | — | — | 8 | 3 | 2 | — | 1 |
| 120.—Acute Yellow Atrophy of the Liver ... | 3 | — | 1 | 2 | — | — | — | — |
| 121.—Hydatid Tumour of the Liver ... | — | — | — | — | — | — | — | — |
| 122.—Cirrhosis of the Liver— | | | | | | | | |
| <i>a.</i> Specified as alcoholic ... | — | — | — | — | — | — | — | — |
| <i>b.</i> Not specified as alcoholic ... | 40 | — | 3 | 28 | 4 | 2 | 1 | 2 |
| 123.—Biliary Calculi ... | — | — | — | — | — | — | — | — |
| 124.—Other Diseases of the Liver ... | — | — | — | — | — | — | — | — |
| <i>a.</i> Abscess of Liver (Amœbiasis) ... | 17 | — | — | 12 | 4 | — | — | 1 |
| <i>b.</i> Others under this title ... | 18 | 3 | — | 8 | 5 | — | — | 2 |
| 125.—Diseases of the Pancreas ... | — | — | — | — | — | — | — | — |
| 126.—Peritonitis without specified cause ... | 40 | 2 | — | 27 | 9 | 2 | — | — |
| 127.—Other Diseases of the Digestive System ... | 1 | — | — | 1 | — | — | — | — |

(11) *Causes of Deaths, &c.*—contd.

| Causes of Death. | Nationality. | | | | | | | |
|--|--------------|------------|-----------|------------|---------|--------|---------|---------|
| | All Races. | Europeans. | Burghers. | Sinhalese. | Tamils. | Moors. | Malays. | Others. |
| XIII—OLD AGE. | | | | | | | | |
| 164.—Senility | 495 | 1 | 20 | 245 | 70 | 122 | 27 | 10 |
| XIV.—EXTERNAL CAUSES. | | | | | | | | |
| 165.—Suicide by Solid or Liquid Poisons (Corrosive substances excepted) .. | 1 | — | — | 1 | — | — | — | — |
| 166.—Suicide by Corrosive substances ... | 2 | — | — | 1 | 1 | — | — | — |
| 167.—Suicide by Poisonous Gas ... | — | — | — | — | — | — | — | — |
| 168.—Suicide by Hanging or Strangulation ... | 12 | — | 1 | 5 | 4 | — | — | 2 |
| 169.—Suicide by Drowning ... | 4 | — | — | 2 | 2 | — | — | — |
| 170.—Suicide by Firearms ... | 2 | — | 1 | — | 1 | — | — | — |
| 171.—Suicide by Cutting or Piercing Instrument ... | 2 | — | — | 1 | — | — | — | 1 |
| 172.—Suicide by Jumping from high places ... | — | — | — | — | — | — | — | — |
| 173.—Suicide by Crushing ... | 2 | — | — | 2 | — | — | — | — |
| 174.—Suicide by other means ... | 2 | — | — | 1 | 1 | — | — | 1 |
| 175.—Poisoning by Food ... | 1 | — | — | 1 | — | — | — | — |
| 176.—Poisoning by Venomous Bites and Stings— | | | | | | | | |
| <i>a.</i> Snake-bite ... | 2 | — | — | 1 | 1 | — | — | — |
| <i>b.</i> Insect Stings ... | — | — | — | — | — | — | — | — |
| <i>c.</i> Other Venomous Poisonings ... | — | — | — | — | — | — | — | — |
| 177.—Other Acute Accidental Poisonings ... | 1 | — | 1 | — | — | — | — | — |
| 178.—Conflagration ... | 1 | — | — | 1 | — | — | — | — |
| 179.—Accidental Burns (Conflagration excepted) . | 24 | — | — | 19 | 2 | 3 | — | — |
| 180.—Accidental Mechanical Suffocation ... | 1 | — | — | 1 | — | — | — | — |
| 181.—Accidental Absorption of Irrespirable, Irritating, or Poisonous Gas ... | 4 | — | — | 1 | 2 | 1 | — | — |
| 182.—Accidental Drowning ... | 19 | — | — | 10 | 4 | 2 | 1 | 2 |
| 183.—Accidental Traumatism by Firearms (wounds of war excepted) ... | — | — | — | — | — | — | — | — |
| 184.—Accidental Traumatism by Cutting or Piercing Instruments ... | — | — | — | — | — | — | — | — |
| 185.—Accidental Traumatism by Falls— | | | | | | | | |
| <i>a.</i> From trees ... | 7 | — | — | 6 | 1 | — | — | — |
| <i>b.</i> From heights other than trees ... | — | — | — | — | — | — | — | — |
| <i>c.</i> Traumatism by other Accidental Fall ... | 21 | 1 | — | 9 | 7 | 2 | — | 2 |
| 186.—Accidental Traumatism in Mines and Quarries ... | — | — | — | — | — | — | — | — |
| 187.—Accidental Traumatism by Machines ... | 4 | — | — | 2 | 1 | — | — | 1 |
| 188.—Accidental Traumatism by other crushing— | | | | | | | | |
| <i>a.</i> Cart or Carriage ... | 6 | — | — | 3 | 1 | 2 | — | — |
| <i>b.</i> Landslides ... | — | — | — | — | — | — | — | — |
| <i>c.</i> Motor Vehicles ... | 14 | — | — | 9 | 2 | 2 | — | 1 |
| <i>d.</i> Railways ... | 13 | 1 | — | 5 | 3 | 2 | 1 | 1 |
| <i>e.</i> Others under this title ... | 11 | — | 1 | 6 | 1 | 1 | — | 2 |
| 189.—Injuries by Animals (poisoning by venomous bites and stings excepted) ... | 2 | — | — | 1 | 1 | — | — | — |
| 190.—Wounds of War ... | — | — | — | — | — | — | — | — |
| 191.—Execution of Civilians by Belligerent Armies. | — | — | — | — | — | — | — | — |
| 192.—Starvation (Hunger or Thirst) ... | — | — | — | — | — | — | — | — |
| 193.—Excessive Cold ... | — | — | — | — | — | — | — | — |
| 194.—Excessive Heat ... | 2 | 1 | — | — | — | 1 | — | — |
| 195.—Lightning ... | — | — | — | — | — | — | — | — |
| 196.—Electricity (Lightning excepted) ... | — | — | — | — | — | — | — | — |
| 197.—Homicide by Firearms ... | — | — | — | — | — | — | — | — |
| 198.—Homicide by Cutting or Piercing Instruments ... | 17 | — | — | 13 | 3 | 1 | — | — |
| 199.—Homicide by other means ... | 5 | — | — | 5 | — | — | — | — |
| 200.—Infanticide (murder of infant less than 1 year of age) ... | — | — | — | — | — | — | — | — |
| 201.—Fractures (cause not specified) ... | 2 | — | — | 2 | — | — | — | — |
| 202.—Other External Violence— | | | | | | | | |
| <i>a.</i> Judicial Execution ... | 27 | — | — | 22 | 2 | 2 | — | 1 |
| <i>b.</i> Others under this title ... | 6 | — | — | 1 | 3 | — | — | 2 |
| 203.—Violent deaths of unknown causation ... | — | — | — | — | — | — | — | — |
| XV.—ILL-DEFINED DISEASES. | | | | | | | | |
| 204.—Sudden death ... | — | — | — | — | — | — | — | — |
| 205.—Cause of death not specified or ill-defined— | | | | | | | | |
| <i>a.</i> Dropsy ... | 1 | — | 1 | — | — | — | — | — |
| <i>b.</i> Heart Failure ... | 29 | — | — | 20 | 4 | 4 | — | 1 |
| <i>c.</i> Pyrexia ... | 58 | 1 | — | 41 | 8 | 7 | 1 | — |
| <i>d.</i> Other Ill-defined diseases ... | 205 | — | 7 | 109 | 41 | 36 | 8 | 4 |
| <i>e.</i> Not specified unknown ... | 1 | — | — | — | — | — | — | 1 |

DIAGRAM N^o III COMPARATIVE CHART

SHOWING
THE MORTALITY FROM THE PRINCIPAL DISEASES DURING THE YEAR 1928
(a) all ages

| | | | | | | | | | | | | | |
|---------------|------------|-----------|-----------------------|---------------|----------------------|-----------|----------|-----------------------|----------|---------------------|--------------|-----------|------------------|
| ENTERIC FEVER | BRONCHITIS | DYSENTERY | INFANTILE CONVULSIONS | UNDER 5 YEARS | INTESTINAL PARASITES | INFLUENZA | SENILITY | DIARRHOEA & ENTERITIS | PHTHISIS | CONGENITAL DEBILITY | UNDER 1 YEAR | PNEUMONIA | ALL OTHER CAUSES |
|---------------|------------|-----------|-----------------------|---------------|----------------------|-----------|----------|-----------------------|----------|---------------------|--------------|-----------|------------------|

(b) Infants

| | | | | | | |
|--------------------|-----------|-------------|---------------------|-----------------|------------|------------------|
| ATROPHY & DEBILITY | PNEUMONIA | CONVULSIONS | DIARRHOEAL DISEASES | PREMATURE BIRTH | BRONCHITIS | ALL OTHER CAUSES |
|--------------------|-----------|-------------|---------------------|-----------------|------------|------------------|

VI.—INFANT MORTALITY.

The total number of infant deaths during 1928 was 1,714, representing a death-rate of 181 as against a death-rate of 187 for 1927. Although the infant mortality rate is still very high it is gratifying to be able to state that the rate for 1928 is the lowest on record in Colombo, *vide* Diagram II., Chart C, and Statement 12.

Reference to Statement 13 will show that by far the largest number of deaths, 636 or 37·1 per cent., was due to atrophy and debility. There is little doubt that the large number of deaths from this cause is due primarily to the excessive poverty and bad housing of the labouring classes and secondarily to the ignorance of the mother, especially with regard to infant-feeding.

That there is very much to be done in the way of Maternity and Child Welfare work both by Municipal and private organizations is only too apparent from the above figures. In spite of the economic conditions of the poor, Child Welfare work alone if carried out systematically and earnestly must by itself help to reduce the infant mortality a good deal. If the educated and rich who live in the lap of luxury will only think of the poor innocent babe born in the squalor of the slums and will only contribute a very little either in point of time or money, a large number of babies who are born only to perish in the first year of their lives will surely will be saved. The Social Service League and the Child Welfare Association are doing as much as they can in this direction, and let us hope that those who are not working with these commendable organizations will join them at the earliest opportunity and help to reduce this very high infant mortality which is a slur on the community at present.

The next in order comes pneumonia, 212 or 12·4 per cent., closely followed by convulsions, 208 or 12·1 per cent. The number of deaths due to pneumonia showed an increase by one on that of 1927, while the number of deaths due to convulsions showed a decrease by 48.

With the opening in a short time of the Child Welfare Centre at Maligakanda and the advent of the new Medical Officer in charge of Maternity and Child Welfare who has just been appointed it is hoped that this high infant mortality will be able to be reduced still further.

By race the highest infant mortality is among the Tamils, who form by far the largest percentage of the cooly classes notorious for their ignorance and poverty. Whichever way this matter is looked upon, it is undeniably seen to be a social question, and as such voluntary and private organizations can do just as much as or more than Municipal bodies in the reduction of this high infant death-rate. In this connection it is pleasing to note the ungrudging way in which the Council has treated all matters concerning the Child Welfare work undertaken by this department. No doubt the value of this branch of the service has been fully realized, and it is hoped that in the future the same policy will be followed, bearing in mind the following words of Sir Arthur Newsholme: "There is nothing so extravagant as inadequate expenditure on public health work."

(12) *Births and Infantile Deaths and the Infant Mortality Rates for Colombo Town, 1919 to 1928.*

| Year. | No. of Births. | No. of Infant Deaths. | Infant Mortality. Rate per 1,000 Births. |
|-------|----------------|-----------------------|---|
| 1919 | 5,907 | 1,603 | 271 |
| 1920 | 7,197 | 1,679 | 233 |
| 1921 | 8,724 | 2,098 | 240 |
| 1922 | 6,881 | 1,702 | 247 |
| 1923 | 7,107 | 1,929 | 271 |
| 1924 | 6,887 | 1,643 | 239 |
| 1925 | 7,663 | 1,689 | 220 |
| 1926 | 8,114 | 1,658 | 204 |
| 1927 | 8 491 | 1,584 | 187 |
| 1928 | 9,486 | 1,714 | 181 |

(13) *Principal Causes of Infant Mortality in 1928.*

Expressed as a Percentage of Total Infant Deaths.

| Cause of Death. | No. of Deaths. | Percentage of Total Infant Deaths. |
|----------------------|----------------|---------------------------------------|
| Convulsions | 208 | 12·1 |
| Atrophy and Debility | 636 | 37·1 |
| Diarrhœal Diseases | 167 | 9·7 |
| Pneumonia | 212 | 12·4 |
| Premature Birth | 151 | 8·8 |

(14) *Infant Deaths during each Quarter, 1928.*

| Cause of Death. | | 1st Quarter. | 2nd Quarter. | 3rd Quarter. | 4th Quarter |
|-----------------|----------------------|--------------|--------------|--------------|-------------|
| Developmental | Atrophy and Debility | 142 | 160 | 147 | 187 |
| | Premature Birth | 37 | 33 | 45 | 36 |
| Respiratory | Bronchitis | 12 | 16 | 8 | 9 |
| | Pneumonia | 36 | 64 | 52 | 60 |
| | Diarrhœal Diseases | 43 | 40 | 42 | 42 |
| | Convulsions | 38 | 51 | 42 | 77 |
| Total | | 308 | 364 | 336 | 411 |

(15) *Infant Mortality by Race, 1928—Number of Infant Deaths and Rate per 1,000 Births.*

| Race. | | No. of Infant Deaths, 1928. | | Rate per 1,000 Births, 1928. | | Rate per 1,000 Births previous Year. | | Increase or Decrease of 1928 Rate when compared with 1927 Rate. | |
|-----------|-----|-----------------------------------|-------|------------------------------------|-----|--|-----|--|-----|
| All Races | ... | ... | 1,714 | ... | 181 | ... | 187 | ... | — 6 |
| Europeans | ... | ... | 2 | ... | 22 | ... | 11 | ... | +11 |
| Burghers | ... | ... | 73 | ... | 122 | ... | 77 | ... | +45 |
| Sinhalese | ... | ... | 982 | ... | 175 | ... | 180 | ... | — 5 |
| Tamils | ... | ... | 274 | ... | 218 | ... | 245 | ... | —27 |
| Moors | ... | ... | 285 | ... | 205 | ... | 224 | ... | —19 |
| Malays | ... | ... | 57 | ... | 164 | ... | 174 | ... | —10 |
| Others | ... | ... | 41 | ... | 206 | ... | 203 | ... | + 3 |

(16) *Infant Mortality, 1928, by Wards—Rate per 1,000 Births.*

| Ward. | | Average, 1918 to 1927. | | 1927. | | 1928. | | Increase or Decrease of 1928 Rate when compared with 1927. | |
|------------------|-----|---------------------------|---------|-------|-----|-------|-----|--|-----|
| Colombo Town... | ... | ... | 238 | ... | 187 | ... | 181 | ... | — 6 |
| Fort | ... | ... | 142 | ... | — | ... | — | ... | — |
| Pettah | ... | ... | 364 | ... | 259 | ... | 233 | ... | —26 |
| San Sebastian | ... | ... | 333 | ... | 279 | ... | 206 | ... | —73 |
| St. Paul's | ... | ... | 395 | ... | 285 | ... | 219 | ... | —66 |
| Kotahena | ... | ... | } 257 { | ... | 215 | ... | 239 | ... | 24 |
| Mutwal | ... | ... | | ... | 209 | ... | 225 | ... | 16 |
| New Bazaar | ... | ... | 345 | ... | 260 | ... | 233 | ... | —27 |
| Maradana North | ... | ... | } 271 { | ... | 213 | ... | 236 | ... | 23 |
| Maradana South | ... | ... | | ... | 243 | ... | 239 | ... | — 4 |
| Dematagoda | ... | ... | | ... | 202 | ... | 197 | ... | — 5 |
| Slave Island | ... | ... | 270 | ... | 157 | ... | 235 | ... | 78 |
| Kollupitiya | ... | ... | } 204 { | ... | 160 | ... | 120 | ... | —40 |
| Cinnamon Gardens | ... | ... | | ... | 156 | ... | 152 | ... | — 4 |
| Bambalapitiya | ... | ... | } 197 { | ... | 105 | ... | 104 | ... | — 1 |
| Timbirigasyaya | ... | ... | | ... | 224 | ... | 143 | ... | —81 |
| Wellawatta | ... | ... | | ... | 163 | ... | 117 | ... | —46 |
| Hospitals | ... | ... | 159 | ... | 131 | ... | 130 | ... | — 1 |

(17) *Infant Mortality, by Race, during the Year 1928—Rate per 1,000 Births.*

| Cause. | All Races. | Europeans. | Burghers. | Sinhalese. | Tamils. | Moors. | Malays. | Others |
|----------------------|------------|------------|-----------|------------|---------|---------|---------|---------|
| All Causes | ... 181 | ... 22 | ... 122 | ... 175 | ... 218 | ... 205 | ... 164 | ... 206 |
| Premature Birth | ... 16 | ... — | ... 10 | ... 19 | ... 20 | ... 7 | ... 3 | ... 5 |
| Atrophy and Debility | 67 | ... | 42 | 58 | 87 | 98 | 55 | 111 |
| Bronchitis | ... 5 | ... — | ... 5 | 4'4 | 5 | 5 | 9 | 5 |
| Pneumonia | ... 22 | ... — | ... 20 | 24 | 26 | 17 | 17 | 15 |
| Diarrhoeal Diseases | ... 18 | ... — | ... 20 | 19 | 16 | 13 | 17 | 5 |
| Convulsions | ... 22 | ... 11 | ... 5 | 22 | 27 | 24 | 20 | 30 |
| Tetanus | ... 1 | ... — | ... — | 0'5 | 4 | 3 | — | — |
| All Other causes | ... 30 | ... 11 | ... 20 | 28 | 33 | 38 | 43 | 35 |

(18) (a) *Causes of Infant Mortality, 1919 to 1928—Number of Deaths.*

| Cause of Infant Deaths. | 1919 | 1920 | 1921 | 1922 | 1923 | Average, 1919-1923 | 1924 | 1925 | 1926 | 1927 | 1928 |
|--------------------------|---------|------|------|------|------|-----------------------|------|------|------|------|------|
| Developmental Diseases | ... 598 | 498 | 706 | 603 | 685 | 618 | 617 | 602 | 609 | 676 | 820 |
| Pneumonia and Bronchitis | ... 220 | 228 | 311 | 251 | 263 | 255 | 213 | 241 | 228 | 254 | 257 |
| Digestive Diseases | ... 201 | 220 | 279 | 225 | 262 | 237 | 235 | 220 | 226 | 202 | 194 |
| Convulsions | ... 418 | 590 | 602 | 411 | 480 | 500 | 409 | 426 | 420 | 256 | 208 |
| Tetanus Neonatorm | ... 17 | 17 | 16 | 17 | 7 | 15 | 22 | 13 | 18 | 9 | 12 |
| Tuberculosis | ... 5 | 6 | 19 | 9 | 10 | 10 | 4 | 2 | — | 1 | — |
| Infectious Diseases | ... 3 | 6 | 7 | 2 | 6 | 5 | 1 | 3 | 3 | 2 | 2 |
| Syphilis | ... 37 | 33 | 33 | 44 | 59 | 41 | 36 | 37 | 34 | 29 | 31 |

(18) (b) Causes of Infant Mortality, 1919 to 1928—Rate per 1,000 Births.

| Cause of Infant Deaths. | 1919 | 1920 | 1921 | 1922 | 1923 | Average, 1919-1923 | 1924 | 1925 | 1926 | 1927 | 1928 |
|------------------------------|------|------|------|------|------|-----------------------|------|------|------|------|------|
| Developmental Diseases ... | 100 | 69 | 81 | 88 | 96 | 87 | 90 | 78 | 75 | 80 | 86 |
| Pneumonia and Bronchitis ... | 37 | 32 | 36 | 36 | 37 | 36 | 31 | 31 | 28 | 30 | 27 |
| Digestive Diseases ... | 34 | 31 | 32 | 33 | 37 | 33 | 34 | 29 | 28 | 24 | 20 |
| Convulsions ... | 71 | 82 | 69 | 60 | 68 | 70 | 59 | 56 | 52 | 30 | 22 |
| Tetanus Neonatorum ... | 3 | 2 | 2 | 2 | 1 | 2 | 3 | 2 | 2.2 | 1.1 | 1 |
| Tuberculosis ... | 1 | 1 | 2 | 1 | 1 | 1 | 0.6 | 0.3 | — | 0.1 | — |
| Infectious Diseases ... | 0.5 | 1 | 1 | 0.6 | 1 | 0.8 | 0.1 | 0.4 | 0.4 | 0.2 | 0.2 |
| Syphilis ... | 6 | 5 | 4 | 6 | 8 | 6 | 5 | 5 | 4 | 3.2 | 3.3 |

(19) Infant Mortality—Deaths at different Age Periods and from Several Causes.

| Causes of Death. | Age. | | | | | | | | | | | | Race. | | | | | | | | |
|---|---------------|-----|-----|-----|--------|----------------|-----|-----|-----|-----|------|-------|------------|-----------|------------|---------|--------|---------|---------|------------|--------|
| | Age in Weeks. | | | | | Age in Months. | | | | | | | Europeans. | Burghers. | Sinhalese. | Tamils. | Moors. | Malays. | Others. | All Races. | |
| | 1 | 2 | 3 | 4 | Total. | 2 | 3 | 4 | 5 | 6 | 7-9 | 10-12 | | | | | | | | | Total. |
| I.—Developmental Diseases:— | | | | | | | | | | | | | | | | | | | | | |
| 1. Premature birth ... | 125 | 13 | 6 | 1 | 145 | 4 | 2 | — | — | — | — | — | 6 | — | 6 | 108 | 25 | 10 | 1 | 1 | 151 |
| 2. Atlectasis ... | 1 | — | — | — | 1 | — | — | — | — | — | — | — | — | — | — | 1 | — | — | — | — | 1 |
| 3. Atrophy and Debility ... | 238 | 80 | 38 | 37 | 393 | 49 | 45 | 31 | 22 | 21 | 45 | 30 | 243 | — | 25 | 324 | 109 | 137 | 19 | 22 | 636 |
| 4. Others ... | 17 | — | — | — | 17 | 2 | — | 2 | — | 2 | 7 | 2 | 15 | — | 3 | 14 | 2 | 9 | 3 | 1 | 32 |
| II.—Diseases of Respiratory System:— | | | | | | | | | | | | | | | | | | | | | |
| 1. Laryngitis ... | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 2. Croup ... | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 3. Bronchitis ... | — | — | — | — | — | 4 | — | 4 | 4 | 5 | 18 | 10 | 45 | — | 3 | 25 | 6 | 7 | 3 | 1 | 45 |
| 4. Pneumonia ... | — | 1 | 1 | 2 | 4 | 4 | 13 | 20 | 21 | 20 | 57 | 73 | 208 | — | 12 | 134 | 33 | 24 | 6 | 3 | 212 |
| 5. Others ... | — | — | — | — | — | — | — | — | — | — | — | 1 | 1 | — | — | 1 | — | — | — | — | 1 |
| III.—Diseases of Digestive System:— | | | | | | | | | | | | | | | | | | | | | |
| 1. Diarrhoeal ... | 3 | 3 | 4 | 4 | 14 | 9 | 20 | 21 | 13 | 9 | 44 | 37 | 153 | — | 12 | 110 | 20 | 18 | 6 | 1 | 167 |
| 2. Worms ... | — | — | — | — | — | — | — | — | 1 | — | 6 | 9 | 16 | — | — | 7 | 2 | 7 | — | — | 16 |
| 3. Others ... | 1 | 3 | 1 | — | 5 | 3 | — | — | 1 | — | 1 | 1 | 6 | — | — | 4 | 3 | 2 | 2 | — | 11 |
| IV.—Diseases of Nervous System:— | | | | | | | | | | | | | | | | | | | | | |
| 1. Convulsions ... | 31 | 19 | 6 | 7 | 63 | 21 | 20 | 25 | 12 | 19 | 29 | 19 | 145 | 1 | 3 | 124 | 34 | 33 | 7 | 6 | 208 |
| 2. Laryngismus streidulus ... | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 3. Tetanus ... | 2 | 10 | — | — | 12 | — | — | — | — | — | — | — | — | — | — | 3 | 5 | 4 | — | — | 12 |
| 4. Others ... | — | 1 | — | 1 | 2 | — | 1 | — | — | 1 | 1 | 3 | 6 | — | 3 | 3 | 2 | — | — | — | 8 |
| V.—Tuberculous Diseases:— | | | | | | | | | | | | | | | | | | | | | |
| 1. Tabes messenterica ... | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 2. Tubercular meningitis ... | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 3. Others ... | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| VI.—Accidents:— | | | | | | | | | | | | | | | | | | | | | |
| 1. Injury ... | 2 | — | — | — | 2 | — | — | — | — | — | — | — | — | 1 | — | 1 | — | — | — | — | 2 |
| 2. Umbilical hæmorrhage ... | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 3. Suffocation ... | 3 | — | — | — | 3 | — | — | — | — | — | — | — | — | — | 1 | 1 | 1 | — | — | — | 3 |
| 4. Other violence ... | 4 | — | — | — | 4 | — | — | — | — | — | — | 1 | 1 | — | — | 4 | 1 | — | — | — | 5 |
| VII.—Epidemic, Endemic, and Infectious Diseases:— | | | | | | | | | | | | | | | | | | | | | |
| 1. Smallpox ... | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 2. Chickenpox ... | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 3. Measles ... | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 4. Whooping cough ... | — | — | — | — | — | 1 | — | — | — | — | 1 | — | 2 | — | — | — | 1 | 1 | — | — | 2 |
| 5. Mumps ... | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 6. Diphtheria ... | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 7. Cerebro-spinal fever ... | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 8. Scarlet fever ... | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| VIII.—Syphilis ... | — | 1 | 2 | 4 | 7 | 3 | 9 | 6 | 1 | 3 | 1 | 1 | 24 | — | 1 | 25 | 4 | — | 1 | — | 31 |
| IX.—All Other causes ... | 3 | 3 | 2 | 5 | 13 | 18 | 22 | 23 | 13 | 15 | 30 | 37 | 158 | — | 4 | 93 | 26 | 33 | 9 | 6 | 171 |
| Total ... | 430 | 134 | 60 | 61 | 685 | 118 | 132 | 132 | 88 | 95 | 240 | 224 | 1029 | 2 | 73 | 982 | 274 | 285 | 57 | 41 | 1714 |
| Percentage on Total Infant Deaths .. | 25.1 | 7.8 | 3.5 | 3.6 | 40.0 | 6.9 | 7.7 | 7.7 | 5.1 | 5.5 | 14.0 | 13.1 | 60.0 | 1.2 | 4.3 | 57.3 | 16.0 | 16.6 | 3.3 | 2.4 | — |

VII.—INFECTIOUS DISEASES. (GENERAL.)

Statements 20 and 21 give the incidence of the principal infectious diseases in the town for 1919-1928.

Plague showed a decrease of 43 cases from that of 1927 and there was a slight diminution in the number of cases of continued fever.

Chickenpox and measles occurred in an epidemic form, the former chiefly during the first five months of the year, and the latter during the last five months.

Phthisis showed an increase of 100 cases over that of the previous year while among most of the other infectious diseases there was only a slight variation.

(20) *Infectious Diseases Recorded (Town Cases), 1919 to 1928.*

| Diseases. | 1919 | 1920 | 1921 | 1922 | 1923 | 1924 | 1925 | 1926 | 1927 | 1928 |
|--|-------|-------|-------|-------|-------|-------|-------|-------|------|-------|
| Plague ... | 87 | 235 | 184 | 136 | 230 | 148 | 64 | 13 | 83 | 40 |
| Cholera ... | — | — | — | — | — | 1 | 3 | — | — | 1 |
| Smallpox ... | 3 | 75 | 12 | 34 | 3 | 4 | 1 | 10 | 2 | 10 |
| Chickenpox ... | 495 | 639 | 711 | 699 | 1,235 | 790 | 1,703 | 1,045 | 887 | 1,520 |
| Measles ... | 399 | 1,062 | 190 | 226 | 761 | 650 | 627 | 518 | 102 | 612 |
| Diphtheria ... | 13 | 7 | 20 | 16 | 19 | 11 | 14 | 17 | 18 | 20 |
| Enteric Fever ... | 512 | 677 | 398 | 341 | 535 | 415 | 473 | 249 | 206 | 230 |
| Continued Fever and “suspected Enteric” ... | 141 | 162 | 187 | 115 | 105 | 231 | 243 | 168 | 136 | 127 |
| Phthisis ... | 1,285 | 1,361 | 1,367 | 1,181 | 1,343 | 1,204 | 1,146 | 977 | 810 | 910 |

(21) *Notifiable Infectious Diseases, 1928.*

| Diseases. | (a) | | | | | | | | | | | | (b) | (c) | (d) | (e) | (f) |
|---------------------|----------|-----------|--------|--------|------|-------|-------|---------|------------|----------|-----------|-----------|-------------------|------------|----------------|--------------------|-------------------------|
| | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Total Town Cases. | Port Cases | Outside Cases. | Grand Total, 1928. | Total Town Cases, 1928. |
| Plague ... | 4 | 10 | 9 | — | 4 | 2 | — | 1 | 2 | 1 | 1 | 6 | 40 | — | 6 | 46 | 83 |
| Cholera ... | — | — | — | — | — | — | 1 | — | — | — | — | — | 1 | 1 | — | 2 | — |
| Smallpox ... | 2 | 8 | — | — | — | — | — | — | — | — | — | — | 10 | 1 | — | 11 | 2 |
| Chickenpox ... | 166 | 258 | 383 | 209 | 101 | 73 | 93 | 66 | 43 | 54 | 42 | 32 | 1,520 | 15 | 64 | 1,599 | 887 |
| Measles ... | 21 | 21 | 12 | 19 | 14 | 18 | 36 | 89 | 55 | 79 | 99 | 149 | 612 | 5 | 40 | 657 | 102 |
| Diphtheria ... | 2 | 4 | 1 | 2 | 3 | 1 | 2 | 2 | 1 | — | 2 | — | 20 | — | 10 | 30 | 18 |
| Acute Diarrhœa ... | — | — | — | — | — | — | — | — | 3 | — | 1 | 1 | 5 | — | 1 | 6 | 1 |
| Enteric fever ... | 27 | 29 | 24 | 19 | 17 | 11 | 10 | 25 | 15 | 18 | 19 | 16 | 230 | 6 | 290 | 526 | 206 |
| Continued Fever ... | 13 | 13 | 10 | 14 | 7 | 10 | 12 | 13 | 12 | 8 | 9 | 6 | 127 | 2 | 38 | 167 | 136 |
| Phthisis ... | 85 | 82 | 76 | 76 | 89 | 80 | 71 | 83 | 64 | 62 | 78 | 64 | 910 | 12 | 455 | 1,377 | 810 |
| Scarlet Fever ... | — | — | — | — | — | — | — | — | — | — | — | — | — | 1 | — | 1 | — |
| Typhus Fever ... | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Total ... | 320 | 425 | 515 | 339 | 235 | 195 | 225 | 279 | 195 | 222 | 251 | 274 | 3,475 | 43 | 904 | 4,422 | 2,245 |

VIII.—PLAGUE.

Human Plague.—During the year 1928 forty cases of human plague, 37 of which were fatal, occurred in the City, this being the second lowest number of cases or deaths on record since its first appearance in 1914.

The case mortality per cent. was 92·5 as against 93·6, the average for the years 1918–1927.

Varieties.—Out of the 40 cases 27 were of the bubonic type and 13 septicæmic. All the septicæmic cases proved fatal, while the three recoveries were among those suffering from bubonic plague. No pneumonic or cutaneous cases were reported during the year.

Distribution.—The largest number of cases occurred in Pettah Ward, the number being eleven. This is not surprising since the granaries are all situated in this Ward. The next in order were St. Paul's and Mutwal with seven cases each, showing that out of a total of 40 cases 62·5 per cent. occurred in these three Wards.

It is very pleasing to note that no cases occurred in Maradana South, which was in 1927 the Ward with the third highest incidence, viz., 11 cases.

The other Wards where no cases occurred during the year were Fort, Kotahena, Bambalapitiya, Timbirigasyaya, and Wellawatta.

Rat Plague.—22,660 rats were examined during the year by Dr. Hirst, the City Microbiologist, and 19 were found to be infected with plague, thus giving a percentage of 0·08 as against 0·15 in 1927. Six of the infected rats were found in the Customs premises and five in Pettah.

The foregoing figures afford the following interesting comparison :—

$$\begin{array}{l} \frac{\text{Percentage of infected rats in 1927}}{\text{Percentage of infected rats in 1928}} = \frac{0\cdot15}{0\cdot08} = \frac{2}{1} \} \dots \text{(approximately).} \\ \frac{\text{Human cases of plague in 1927}}{\text{Human cases of plague in 1928}} = \frac{83}{40} = \frac{2}{1} \} \dots \text{(approximately).} \end{array}$$

Species of Rats.—Statement 28 gives the number of the various species of rats examined, the number found infected, and the percentage infection.

Preventive Measures.—The usual preventive measures are promptly taken as soon as information is received, the method adopted being as follows :—

After immediate compulsory segregation of the inmates of the infected house, it is thoroughly disinfected and pesterined. Then the two houses to the right and left are attended to in the same way and the infected house is done for the second time. Finally the whole block or square of buildings between the nearest four roads is taken in hand. The Claytons start at two adjoining houses furthest from the infected habitation working centripetally to meet at the infected house.

PLAGUE IN 1928 IN THE CITY OF COLOMBO

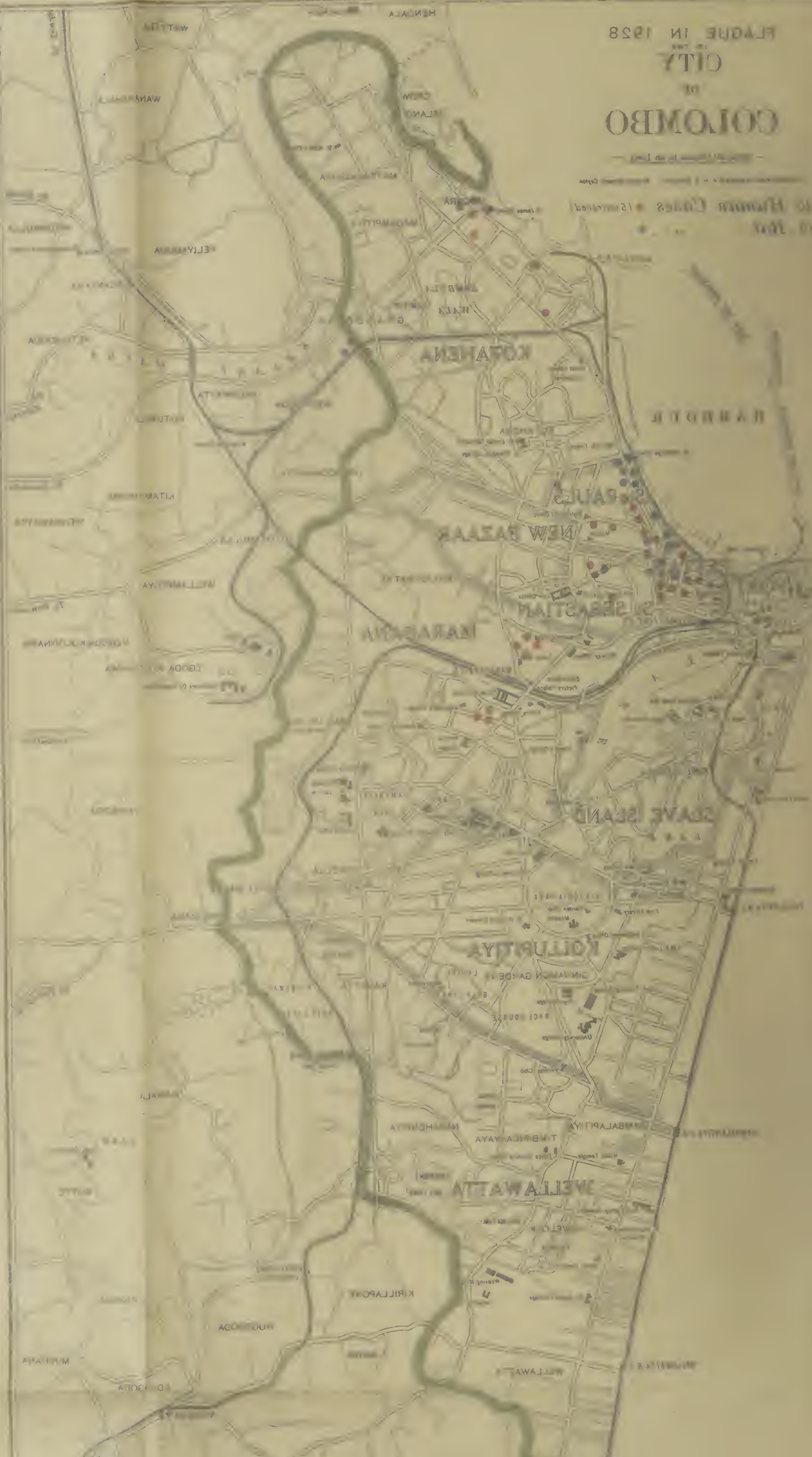
— Scale 50 Chains to an Inch —

Published under the orders of A. H. G. Dawson Surveyor General, Ceylon.

40 Human Cases... (5 untraced)
19 Rat



COLOMBO
OF
CITY
IN 1928
FLAG IN 1928



The houses are unroofed, rat-nests looked for, all rat-holes fumigated and filled with broken glass and cement, the floors pesterined and disinfected and all underground drains fumigated. Rats caught or found dead are sent straightaway to the City Microbiologist for investigation. By this procedure the infected house is disinfected three times, the two adjoining houses twice, and each of the others in the block once. When an infected rat is reported from any dwelling the same routine is gone through.

During the off-season the plague gangs are put on duty in those *Cheopis* infested areas as mapped out by the City Microbiologist.

The work done by the plague staff is given in Statement 31.

General.—In addition to constant risk from re-importation of fresh infection, chiefly, through grain arriving from India and Burma, it may be mentioned here that in Pettah, and St. Pauls' there is yet another danger, in that they have a great number of obsolete underground drains, the existence of which is partly due to the fact that originally these two Wards were residential quarters, and the houses used for business purposes now were at that time used as ordinary dwelling houses by the richer people, and partly owing to the congestion obtaining in these Wards. As soon as any of the premises are connected to the sewer all the old underground drains rendered useless are filled up. A minute search for such drains in the whole area with the aid of the Municipal Engineer is very desirable and it is hoped that this would be possible soon.

The writer's experience has been that soon after a very heavy shower of rain or moderate showers of rain a case or two of plague occurs in these infected areas. It appears that the mere lowering of the temperature by rain is in itself not sufficient to explain the occurrence of such cases so soon after it, and it seems quite possible that these old underground drains may be harbouring infected rats which are forced out by the storm water. In view of the above, the sewerage of every street and the abolition of all such underground drains by compulsory connection of every house to the sewer will most surely be a decided help in our fight against this dreadful disease.

(22) *Annual Incidence of Human Plague Cases, 1914 to 1928.*

| | 1914. | 1915. | 1916. | 1917. | 1918. | 1919. | 1920. | 1921. | 1922. | 1923. | 1924. | 1925. | 1926. | 1927. | Average, 1918-1927 | 1928. |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-----------------------|-------|
| Total cases... | 413 | 139 | 291 | 207 | 70 | 87 | 235 | 184 | 136 | 230 | 148 | 64 | 13 | 83 | 118 | 40 |
| Total deaths | 381 | 128 | 273 | 196 | 69 | 82 | 223 | 170 | 131 | 209 | 140 | 58 | 12 | 76 | 117 | 37 |
| Septicæmic cases | 247* | 81* | 159 | 124 | 41 | 50 | 93 | 70 | 57 | 66 | 47 | 18 | 2 | 32 | 48 | 13 |
| Septicæmic deaths | 246 | 80 | 159 | 124 | 41 | 50 | 93 | 70 | 57 | 66 | 47 | 18 | 2 | 32 | 48 | 13 |
| Bubonic cases | 166 | 58 | 132 | 83 | 29 | 37 | 142 | 114 | 79 | 164 | 94 | 45 | 11 | 51 | 77 | 27 |
| Bubonic deaths | 135 | 48 | 114 | 72 | 28 | 32 | 130 | 100 | 74 | 143 | 86 | 40 | 10 | 44 | 69 | 24 |
| Pneumonic cases | — | — | — | — | — | — | — | — | — | — | 7 | — | — | — | ? | — |
| Pneumonic deaths | — | — | — | — | — | — | — | — | — | — | 7 | — | — | — | ? | — |
| Cutaneous cases | — | — | — | — | — | — | — | — | — | — | — | 1 | — | — | ? | — |
| Cutaneous deaths | — | — | — | — | — | — | — | — | — | — | — | — | — | — | ? | — |
| Total case mortality per cent. ... | 92·2 | 92·8 | 93·8 | 94·7 | 98·6 | 94·3 | 94·9 | 92·4 | 96·3 | 90·9 | 94·5 | 90·6 | 92·3 | 91·6 | 93·6 | 92·5 |
| Septicæmic case mortality per cent. ... | 99·6 | 98·7 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Bubonic case mortality per cent. ... | 81·3 | 82·7 | 86·4 | 86·7 | 96·6 | 86·5 | 91·5 | 87·7 | 93·8 | 87·2 | 91·5 | 88·9 | 90·9 | 86·3 | 90·9 | 88·9 |
| Pneumonic case mortality per cent. ... | — | — | — | — | — | — | — | — | — | — | 100 | — | — | — | — | — |

(23) *Monthly Incidence of Human Plague Cases, 1914 to 1928.*

| Month. | 1914. | 1915. | 1916. | 1917. | 1918. | 1919. | 1920. | 1921. | 1922. | 1923. | 1924. | 1925 | 1926. | 1927. | Average, 1918-1927. | 1928. |
|------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|-------|-------|------------------------|-------|
| January ... | 4 | 19 | 17 | 25 | 13 | — | 25 | 65 | 13 | 28 | 46 | 5 | 1 | 13 | 21 | 4 |
| February ... | 67 | 6 | 18 | 40 | 18 | 1 | 20 | 53 | 10 | 32 | 22 | 6 | 4 | 12 | 18 | 10 |
| March ... | 58 | 3 | 18 | 61 | 10 | 3 | 3 | 27 | 6 | 11 | 7 | 8 | 2 | 19 | 10 | 9 |
| April ... | 28 | 3 | 14 | 34 | 11 | — | 3 | 7 | 2 | 17 | 24 | 6 | 1 | 12 | 8 | — |
| May ... | 29 | 3 | 11 | 11 | 2 | — | 4 | 2 | 7 | 9 | 9 | 1 | — | 8 | 4 | 4 |
| June ... | 49 | 1 | 36 | 3 | 9 | — | 3 | 1 | 8 | 10 | 6 | 10 | 1 | 9 | 6 | 2 |
| July ... | 47 | 5 | 43 | 6 | 2 | — | 12 | 3 | 10 | 21 | 11 | 8 | — | — | 7 | — |
| August ... | 40 | 20 | 35 | 1 | 1 | 2 | 7 | 2 | 7 | 23 | 5 | 8 | — | 2 | 6 | 1 |
| September ... | 18 | 21 | 25 | 3 | — | 5 | 18 | 2 | 7 | 26 | 3 | 5 | — | 4 | 7 | 2 |
| October ... | 23 | 24 | 24 | 7 | — | 18 | 28 | 9 | 14 | 12 | 3 | 1 | — | 1 | 9 | 1 |
| November ... | 24 | 10 | 25 | 10 | 2 | 34 | 34 | 4 | 19 | 13 | 8 | 5 | 2 | 1 | 12 | 1 |
| December ... | 26 | 24 | 25 | 6 | 2 | 24 | 78 | 9 | 33 | 28 | 4 | 1 | 2 | 2 | 18 | 6 |
| Total for year.. | 413 | 139 | 291 | 207 | 70 | 87 | 235 | 184 | 136 | 230 | 148 | 64 | 13 | 83 | 126 | 40 |
| Monthly mean. | 34·4 | 11·6 | 24·3 | 17·3 | 5·8 | 7·3 | 19·6 | 15·3 | 11·3 | 19·2 | 12·3 | 5·3 | 1·1 | 6·9 | 10·5 | 3·3 |

* The cases for 1914 and 1915 include a septicæmic recovery each, but the diagnosis in either case was not confirmed bacteriologically and may have been erroneous.

(24) *Human Plague, 1928—Distribution by Wards.*

| Ward. | No. of Cases. | No. of Deaths. | Ward. | No. of Cases. | No. of Deaths. |
|--------------------|---------------|----------------|------------------------|---------------|----------------|
| Fort ... | — | — | Kollupitiya ... | — | — |
| Pettah ... | 11 | 11 | Cinnamon Gardens ... | — | — |
| San Sebastian ... | 2 | 2 | Bambalapitiya ... | — | — |
| St. Paul's ... | 7 | 7 | Timbirigasyaya ... | — | — |
| Kotahena ... | — | — | Wellawatta ... | — | — |
| Mutwal ... | 7 | 7 | No fixed residence ... | 2 | 2 |
| New Bazaar ... | — | — | Untraced... ... | 3 | 1 |
| Maradana North ... | 4 | 3 | | | |
| Maradana South ... | — | — | Total ... | 40 | 37 |
| Dematagoda .. | 3 | 3 | | | |
| Slave Island ... | 1 | 1 | | | |

(25) *Human Plague in Colombo during the Year 1928—Distribution by Race, Sex, and Age.*

| Race. | Sex. | 0 to 5 Years. | 5 to 10 Years. | 10 to 15 Years. | 15 to 20 Years. | 20 to 25 Years. | 25 to 30 Years. | 30 to 35 Years. | 35 to 40 Years. | 40 to 50 Years. | 50 to 60 Years. | 60 Years and Over. | Total. | Total of each Race. | No. of deaths (inclusive of deaths of Colombo cases at I. D. H.) | Case Mortality per Cent. |
|-----------|---------------|---------------|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|--------------------|--------|---------------------|--|--------------------------|
| All Races | { Males ... | — | — | 2 | 8 | 9 | 4 | 3 | 2 | 5 | — | — | 33 | 40 | 37 | 92.5 |
| | { Females ... | — | 1 | — | 3 | — | 1 | 1 | 1 | — | — | — | 7 | | | |
| Europeans | { Males ... | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| | { Females ... | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Burghers | { Males ... | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| | { Females ... | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Sinhalese | { Males ... | — | — | 2 | — | 3 | — | — | — | — | — | — | 5 | 10 | 10 | 100 |
| | { Females ... | — | 1 | — | 2 | — | 1 | — | 1 | — | — | — | 5 | | | |
| Tamils | { Males ... | — | — | — | 5 | 2 | 1 | 1 | 1 | 2 | — | — | 12 | 13 | 13 | 100 |
| | { Females ... | — | — | — | 1 | — | — | — | — | — | — | — | 1 | | | |
| Moors | { Males ... | — | — | — | 2 | 2 | 1 | 2 | — | 1 | — | — | 8 | 9 | 7 | 77.8 |
| | { Females ... | — | — | — | — | — | — | 1 | — | — | — | — | 1 | | | |
| Malays | { Males ... | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| | { Females ... | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Others | { Males ... | — | — | — | 1 | 2 | 2 | — | 1 | 2 | — | — | 8 | 8 | 7 | 87.5 |
| | { Females ... | — | — | — | — | — | — | — | — | — | — | — | — | | | |

(26) *Human Plague, 1928—Occupational Incidence.*

| | Number. | | Number. |
|----------------------------------|---------|-----------------------|---------|
| Engaged in the grain trade ... | 4 | Commission Agents ... | 3 |
| Coolies ... | 10 | Students ... | 1 |
| Servants in shops and boutiques | 4 | Beggars ... | 1 |
| Domestic servants ... | 1 | Electricians ... | 1 |
| Cooks ... | 2 | No occupation ... | 4 |
| Salesmen and assistants in shops | 5 | | |
| Hawkers ... | 1 | Total ... | 40 |
| Fitters ... | 1 | | |
| Traders ... | 2 | | |

(27) *Statement showing Rats examined at the Laboratory, Number found infected, and Percentage Infection.*

| Month. | No. of Rats examined. | Number infected. | Percentage infection. | Month. | No. of Rats examined. | Number infected. | Percentage infection. |
|--------------|-----------------------|------------------|-----------------------|---------------|-----------------------|------------------|-----------------------|
| January ... | 2,111 | 3 | 0.14 | September ... | 1,606 | — | — |
| February ... | 2,456 | 8 | 0.33 | October ... | 2,124 | 1 | 0.05 |
| March ... | 2,270 | 2 | 0.09 | November ... | 2,125 | 3 | 0.14 |
| April ... | 1,567 | — | — | December ... | 981 | 2 | 0.20 |
| May ... | 1,901 | — | — | | | | |
| June ... | 1,915 | — | — | Total ... | 22,660 | 19 | 0.08 |
| July ... | 1,898 | — | — | | | | |
| August ... | 1,706 | — | — | | | | |

DIAGRAM Nº IV

PLAGUE CASES

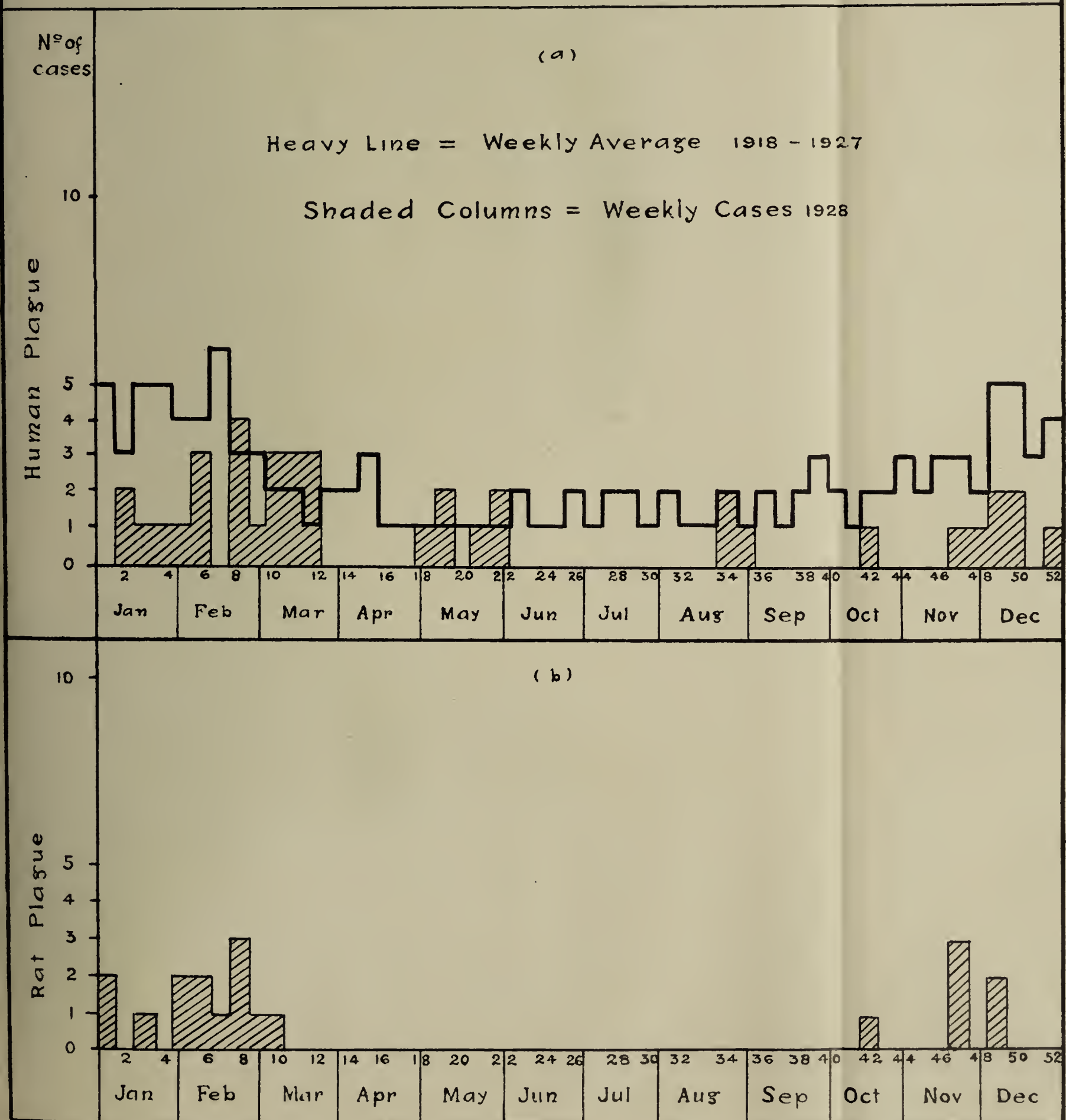
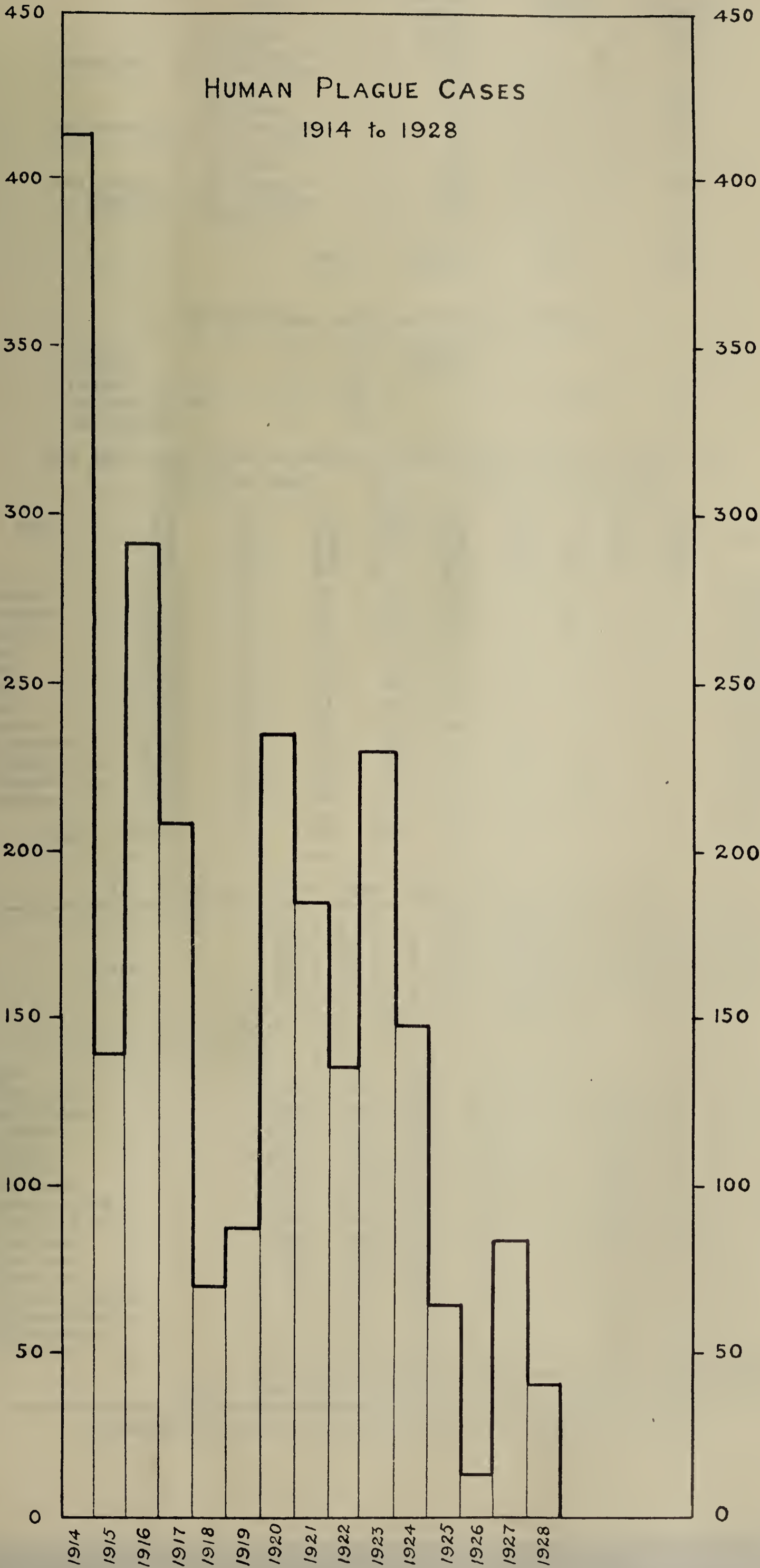


DIAGRAM Nº V



(28) *Distribution of Rodents examined for Plague in 1928.*

| | | Species. | | Number examined. | | Number infected. | | Percentage infection. |
|----------------------------|-----|---------------|-----|---------------------|-----|---------------------|-----|--------------------------|
| Trapped rats | ... | R. Rattus | ... | 15,973 | ... | 4 | ... | 0.03 |
| | | R. Norvegicus | ... | 3,486 | ... | 5 | ... | 0.14 |
| | | M. Musculus | ... | 749 | ... | 0 | ... | — |
| | | Bandicoots | ... | 3 | ... | 0 | ... | — |
| Rats found dead | ... | R. Rattus | ... | 29 | ... | 3 | ... | 10.34 |
| | | R. Norvegicus | ... | 56 | ... | 6 | ... | 10.71 |
| | | M. Musculus | ... | 3 | ... | 0 | ... | — |
| | | | | | | | | |
| Rats killed by Claytons | ... | R. Rattus | ... | 424 | ... | 0 | ... | — |
| | | R. Norvegicus | ... | 1,397 | ... | 1 | ... | 0.07 |
| | | M. Musculus | ... | 530 | ... | 0 | ... | — |
| | | Bandicoots | ... | 10 | ... | 0 | ... | — |
| Total | | | ... | 22,660 | | 19 | | 0.08 |

(29) *Rat Plague, 1928—Distribution by Wards.*

| | | | | | |
|--------------------|-----|-----|------------|-----|----|
| Fort | ... | Nil | St. Paul's | ... | 3 |
| Customs | ... | 6 | Mutwal | ... | 3 |
| Pettah | ... | 5 | | | |
| Chalmers Granaries | ... | Nil | Total | ... | 19 |
| San Sebastian | ... | 2 | | | |

(30) *Rats trapped, killed by Claytons, and found Dead during the Year 1928.*

| Month. | Number of Rats trapped. | | | Number of Rats killed by Claytons. | Number of Rats found Dead. | | | | | Total. |
|-----------|-------------------------|-------------------------|---------------------|--|----------------------------|------------------------|----------------------|-------------------------|---------------------|---------|
| | Veterinary Surgeon. | Chalmers* Granaries. | Manning* Market. | | Mummified Rats. | Veterinary Surgeon. | Plague Inspector. | Chalmers* Granaries. | Manning* Market. | |
| January | 14,127 | 220 | 58 | 181 | 2 | 4 | 17 | — | — | 14,609 |
| February | 12,871 | 268 | 56 | 254 | 1 | 4 | 16 | — | — | 13,470 |
| March | 13,182 | 240 | 52 | 210 | 16 | — | 12 | 2 | — | 13,714 |
| April | 12,647 | 123 | 73 | 53 | — | 3 | 1 | — | — | 12,900 |
| May | 11,745 | 177 | 105 | 91 | — | 2 | — | — | — | 12,120 |
| June | 12,581 | 192 | 89 | 161 | 6 | 2 | 4 | — | — | 13,035 |
| July | 12,947 | 196 | 111 | 140 | — | — | 1 | — | — | 13,395 |
| August | 11,678 | 222 | 86 | 83 | — | 1 | — | 1 | — | 12,071 |
| September | 11,686 | 186 | 88 | 126 | 5 | 4 | 1 | — | — | 12,096 |
| October | 13,071 | 237 | 84 | 107 | — | 2 | 3 | — | — | 13,506 |
| November | 11,484 | 327 | 117 | 189 | 2 | 1 | 5 | — | — | 12,125 |
| December | 11,261 | 347 | 90 | 131 | 1 | — | 5 | — | — | 11,835 |
| Total | 149,280 | 2,735 | 1,009 | 1,726 | 33 | 23 | 65 | 3 | 2 | 154,876 |

(31) *Work done by the Plague Staff during the Year 1928.*

| WARD. | | No. of Dwellings Claytonized. | No. of Dwellings Unroofed. | No. of Rat Holes Claytonized. | No. of Rats killed by Claytons. | No. of Recently Dead Rats found. | No. of Mummified Rats found. | No. of Dwellings Pesterined. | No. of Dwellings Disinfected. | No. of Rat Nests found. | No. of Cart Loads of Rubbish removed. |
|------------------|-----|----------------------------------|-------------------------------|----------------------------------|------------------------------------|-------------------------------------|---------------------------------|---------------------------------|----------------------------------|----------------------------|---|
| Fort | ... | 1 | 1 | 12 | — | — | — | — | — | — | — |
| Pettah | ... | 2,389 | 2,389 | 2,916 | 358 | 22 | 21 | 1,936 | 431 | 16 | 456 ³ / ₄ |
| San Sebastian | ... | 1,986 | 1,986 | 1,127 | 191 | 7 | 5 | 1,455 | 633 | 2 | 73 ³ / ₄ |
| St. Paul's | ... | 4,963 | 4,963 | 3,822 | 556 | 19 | 7 | 2,440 | 2,552 | 8 | 245 ³ / ₄ |
| Kotahena | ... | 376 | 376 | 319 | 13 | — | — | 43 | 202 | — | 11 |
| Mutuwal | ... | 1,429 | 1,429 | 1,728 | 174 | 13 | — | 814 | 624 | 4 | 73 |
| New Bazaar | ... | 1,687 | 1,687 | 1,914 | 107 | — | — | 906 | 801 | 4 | 82 ³ / ₄ |
| Maradana North | ... | 619 | 619 | 731 | 9 | 1 | — | 293 | 317 | — | 40 ¹ / ₄ |
| Maradana South | ... | 1,109 | 1,109 | 1,328 | 107 | 1 | — | 459 | 670 | 11 | 62 ³ / ₄ |
| Dematagoda | ... | 903 | 903 | 917 | 62 | — | — | 204 | 689 | — | 46 |
| Slave Island | ... | 1,339 | 1,339 | 1,487 | 98 | 2 | — | 774 | 579 | 10 | 39 |
| Kollupitiya | ... | 13 | 13 | 45 | 5 | — | — | — | — | — | — |
| Cinnamon Gardens | ... | 1 | 1 | 5 | — | — | — | — | — | — | — |
| Bambalapitiya | ... | 13 | 13 | 79 | 18 | — | — | 2 | 2 | — | 1 |
| Timbirigasyaya | ... | — | — | — | — | — | — | — | — | — | — |
| Wellawatta | ... | 57 | 57 | 177 | 28 | — | — | 18 | 28 | — | 4 |
| Total | ... | 16,885 | 16,885 | 16,607 | 1,726 | 65 | 33 | 9,344 | 7,528 | 55 | 1,136 |

* Figures supplied by the Chairman, Board of Immigration and Quarantine, Colombo.

IX.—CHOLERA.

Only one case of cholera occurred in the town during the year. One other case from a steamer was also reported. The former patient was a workman employed in one of the lighter boats in the harbour and it is probable the infection was from one of the ships. As soon as the case was discovered all the usual precautions were taken which were apparently successful in checking its further progress.

X.—SMALLPOX AND VACCINATION.

Ten cases of smallpox occurred in the City during 1928, two of which were fatal and only one case was reported from ships.

Case No. 1 was reported on January 20, 1928, as a case of "fever with eruptions" and this was diagnosed as a case of smallpox of the confluent type in the pustular stage. The patient was an immigrant from India who came over to seek employment leaving Tatapari camp on December 28, 1927. He was found at 87, Church street, Slave Island, being the sole occupant, the others having forsaken him.

Prompt action was taken in removing the patient to the Infectious Diseases Hospital and a campaign of vaccination was started in the area with daily house to house inspections.

Twenty-three contacts were also despatched to the camp to be kept under observation. There was little doubt that this had been a concealed case as was proved at the subsequent successful prosecution of the chief occupier. The case proved fatal.

Case No. 2 was a contact of Case No. 1 who developed the disease in camp on January 27, 1928.

Case No. 3 occurred in a garden situated just behind 87, Church street, the residence of Case No. 1.

On February 6, 1928, as soon as the case was detected the patient was sent to the Infectious Diseases Hospital together with ten contacts. This case also had been concealed for some time and here too a successful prosecution was entered against the chief occupier.

Case No. 4 was found on the same day and in the same garden as Case No. 3 by the officers of the Public Health Department while doing house to house inspections.

The patient and eight contacts were sent straightaway to the Infectious Diseases Hospital and Camp respectively.

In this instance too a prosecution was entered against the chief occupier, who was found guilty.

Case No. 5 This patient who was residing in the same garden as Cases Nos. 3 and 4 had left the place on the first signs of the disease and gone to a house in Second Maligakanda lane, the residence of his sister, whose husband (Case No. 10) was the caretaker of the Muslim cemetery in Temple road.

Evidently not receiving a fitting welcome he spent a few more days here and there keeping himself in hiding and at last being unable to do anything else reported himself, when in the pustular stage of the disease, at the Slave Island Police Station, from where he was sent to the Infectious Diseases Hospital. Sixteen contacts were also segregated.

Case No. 6 Child of Case No. 4, developed the disease in Camp on February 14, 1928.

Case No. 7 Father of Case No. 3, developed the disease in Camp on February 13, 1928.

Case No. 8 was detected on February 15, 1928, in the same garden as Cases Nos. 3 and 4 during house to house inspections. No eruption was apparent at the time but developed later. The patient and sixteen contacts were sent to Camp.

Case No. 9 was reported from Havelock town on the night of February 23, 1928, and was despatched on the twenty-fourth early morning to the Infectious Diseases Hospital. Eleven contacts were also sent away.

The patient was a driver of a Municipal steam roller and although his residence was in Havelock town he had been working near the infected Church street area in Slave Island. This was one of the two cases that unfortunately proved fatal.

Case No. 10 was the brother-in-law and a contact of Case No. 5. He too developed the disease while he was in Camp.

The epidemic lasted for five weeks, the first case reported being on January 20, 1928, and the last on February 29, 1928, no more cases occurring during the rest of the year.

The occurrence of these cases clearly demonstrates as has been shown year after year that whenever an epidemic of smallpox occurs in Colombo, the first case is always an importation from India, and so long as the immigrant labourers who come in large numbers every year are not detained for the full incubation period of the disease, we must be prepared for a periodic visitation of this dreadful disease.

The Sanitary Inspectors, Sub-Sanitary Inspectors, and Health Visitors who assisted in the vaccinations deserve special commendation for their work in connection with this epidemic.

(32) *Vaccinations performed during the Year 1928.*

(a) By Government Vaccinators.

(Figures supplied by the Provincial Surgeon, Western Province.)

| Station. | Number of Primary Vaccinations. | Number of Re-vaccinations. | Total. |
|---|---------------------------------------|-------------------------------|--------|
| Layard's broadway ... | 536 | — | 536 |
| Kotahena and Alutmawata. | 397 | — | 397 |
| Slave Island ... | 437 | 28 | 465 |
| Silversmith street ... | 342 | — | 342 |
| Bambalapitiya ... | 616 | 274 | 890 |
| Maradana ... | 566 | 46 | 612 |
| San Sebastian street ... | 473 | — | 473 |
| Timbirigasyaya and Dema- tagoda | 650 | 1 | 651 |
| Itinerating ... | 377 | — | 377 |
| Slave Island (special small- pox duty) ... | 5 | 129 | 134 |
| Total ... | 4,399 | 478 | 4,877 |

(b) By the Public Health Department.

| Ward. | Number of Primary Vaccinations. | Number of Re-vaccinations. | Total. |
|--------------------|---------------------------------------|-------------------------------|--------|
| Slave Island ... | 70 | 1,685 | 1,755 |
| Maradana South ... | 30 | 512 | 542 |
| Dematagoda ... | 18 | 286 | 304 |
| Wellawatta ... | 4 | 105 | 109 |
| Total ... | 122 | 2,588 | 2,710 |

(c) Total Vaccinations in Colombo.

| | | |
|--------------------------|-----|-------|
| Primary vaccinations ... | ... | 4,521 |
| Re-vaccinations ... | ... | 3,066 |
| Total ... | ... | 7,587 |

XI.—CHICKENPOX.

The number of cases of chickenpox reported during the year was 1,599, out of which 64 were from outside town limits and 15 port cases, thus making the total number of town cases 1,520.

Statement 33 shows that among the Malayalees alone 825 (or 54·3 per cent.) cases occurred, and, considering that they form only a very small community, this number is extraordinarily high. Apart from the fact that large numbers of them club together in one house there is reason to believe that as a race they are very susceptible to this disease, and as a matter of scientific interest it may be added that they also show an idiosyncrasy for potassium iodide, moderate doses of which produce a typical iodide rash in many instances.

1,117 out of the 1,520 cases occurred during the first five months of the year, and from June onwards there was a definite fall (*vide* Statement 36).

As a very large number of the cases are of a mild type, medical aid is seldom sought for, so that the majority of cases are reported when they are almost recovered, having by that time probably infected the other dwellers in the house.

1,132 cases were between the ages of 15 and 40 years, the largest number, 401, being between 20 and 25 years. It is interesting to note that 7 cases occurred among those between 60 and 70 years, 10 cases between 70 and 80, and 3 cases over 80 years of age. No deaths were reported.

(33) *Chickenpox in Colombo Town during the Year 1928. (Town Cases.)*

Racial Incidence.

| Race. | No. of Cases. | Race. | No. of Cases. |
|---------------|---------------|----------------|---------------|
| Europeans ... | 4 | Malayalees ... | 825 |
| Burghers ... | 75 | Others ... | 3 |
| Sinhalese ... | 312 | | |
| Tamils ... | 172 | | |
| Moors ... | 67 | Total ... | 1,520 |
| Malays ... | 62 | | |

(34) *Chickenpox in Colombo Town during the Year 1928. (Town Cases.)*

Distribution by Ward.

| Ward. | No. of Cases. | Ward. | No. of Cases. |
|--------------------|---------------|--------------------------|---------------|
| Fort ... | 3 | Cinnamon Gardens ... | 16 |
| Pettah ... | 18 | Bambalapitiya ... | 56 |
| San Sebastian... | 31 | Timbirigasyaya ... | 12 |
| St. Paul's ... | 57 | Wellawatta ... | 63 |
| Kotahena ... | 86 | Prisons ... | 5 |
| Mutwal ... | 48 | Vagrants and Paupers ... | 79 |
| New Bazaar ... | 34 | Untraced ... | 179 |
| Maradana North ... | 216 | | |
| Maradana South ... | 96 | | |
| Dematagoda ... | 31 | | |
| Slave Island ... | 456 | Total ... | 1,520 |
| Colpetty ... | 34 | | |

(35) *Chickenpox in Colombo Town during the Year 1928. (Town Cases.)*

Distribution according to Age.

| Age Period. | No. of Cases. | Age Period. | No. of Cases. |
|---------------------------|---------------|---------------------------|---------------|
| Under 1 year ... | 7 | 30 years and under 35 ... | 170 |
| 1 year and under 2 ... | 14 | 35 years and under 40 ... | 115 |
| 2 years and under 3 ... | 8 | 40 years and under 50 ... | 86 |
| 3 years and under 4 ... | 9 | 50 years and under 60 ... | 30 |
| 4 years and under 5 ... | 20 | 60 years and under 70 ... | 7 |
| 5 years and under 10 ... | 95 | 70 years and under 80 ... | 10 |
| 10 years and under 15 ... | 99 | 80 years and over ... | 3 |
| 15 years and under 20 ... | 228 | | |
| 20 years and under 25 ... | 401 | Total ... | 1,520 |
| 25 years and under 30 ... | 218 | | |

(36) *Chickenpox in Colombo Town during the Year 1928. (Town Cases.)*

Monthly Incidence.

| Month. | No. of Cases. | Month. | No. of Cases. |
|--------------|---------------|---------------|---------------|
| January ... | 166 | September ... | 43 |
| February ... | 258 | October ... | 54 |
| March ... | 383 | November ... | 42 |
| April ... | 209 | December ... | 32 |
| May ... | 101 | | |
| June ... | 73 | | |
| July ... | 93 | Total ... | 1,520 |
| August ... | 66 | | |

XII.—MEASLES.

The total number of cases reported during the year was 657. The number of port and outside cases was 45, thus making the number of town cases 612. There occurred during the last five months of the year an extra large number of cases (*vide* Statement 38).

In 1927 only 102 town cases were reported, while in 1926 there were 518 cases. There is little doubt that, unlike in temperate climates, the mortality from measles is very very low, only 2 deaths having been reported in 1928 and none in 1927. Most of the cases are of a very mild type, and the climatic conditions being in favour of the patients fortunately only a very few are complicated with bronchitis or broncho-pneumonia, which is the commonest immediate cause of death in measles. Under these circumstances naturally the average person is apt to treat an attack of measles as a matter of little consequence, regarding it as a disease not of any seriousness but one merely of inconvenience; and it is not rare to see the other children of the house deliberately exposed to infection by ignorant parents so as to "get it over once and for all" as they say.

(37) *Measles Town Cases, 1928.—Number at each Age Period.*

| Age Period. | No. of Cases. | Age Period. | No. of Cases. |
|--------------------|---------------|-----------------------|---------------|
| 0 to 5 years ... | 197 | 35 to 40 years ... | 3 |
| 5 to 10 years ... | 173 | 40 to 50 years ... | — |
| 10 to 15 years ... | 104 | 50 to 60 years ... | — |
| 15 to 20 years ... | 77 | 60 years and over ... | 1 |
| 20 to 25 years ... | 34 | | |
| 25 to 30 years ... | 16 | Total ... | 612 |
| 30 to 35 years ... | 7 | | |

(38) *Monthly Incidence of Measles. (Town Cases only.)*

| Month. | No. of Cases. | Month. | No. of Cases. |
|--------------|---------------|---------------|---------------|
| January ... | 21 | September ... | 55 |
| February ... | 21 | October ... | 79 |
| March ... | 12 | November ... | 99 |
| April ... | 19 | December ... | 149 |
| May ... | 14 | | |
| June ... | 18 | | |
| July ... | 36 | | |
| August ... | 89 | Total ... | 612 |

XIII.—DIPHTHERIA.

Thirty cases with 6 deaths were reported during the year, 10 being from outside town limits. Twenty-four of the cases occurred in children under 12 years of age. Out of the 20 town cases the seat of affection was the throat in 19 cases, the other being one of nasal diphtheria.

From Statement 21 it will be seen that the largest number of cases (4) was reported in February. No cases were notified in October or December.

Fortunately it has not assumed any serious epidemic form but the cases appear to have occurred rather in the nature of isolated ones.

Since these cases are given as reported by qualified medical practitioners there is no reason to doubt the correctness of their diagnosis, and the fact that no serious epidemic occurred may at least be partly due to the efficient manner in which the general practitioners handle these cases apart from the usual precautions taken by this department.

XIV.—DIARRHŒA AND DYSENTERY.

(a) *Diarrhœa and Enteritis.*

The number of deaths from the above cause reported during the year was 572, as against 519 in 1927, the Ward with the largest number being Mutwal (*vide* Section XV., remarks on enteric fever and Mutwal).

(b) *Dysentery.*

Dysentery has, during the year, accounted for 227 deaths.

This has been made a notifiable disease as from January 1, 1929, and as it has not been so prior to this date it is regretted that no details as to its type, rate of incidence, case-mortality, &c., can be given.

(39) *Diarrhœal Diseases, 1928.—Deaths by Race.*

| | All Races. | Euro-peans. | Bur-ghers. | Sin-halese. | Tamils. | Moors. | Malays. | Others. |
|----------------------------|------------|-------------|------------|-------------|---------|--------|---------|---------|
| Diarrhœa and Enteritis ... | 572 | — | 23 | 352 | 112 | 60 | 16 | 9 |
| Dysentery .. | 227 | 3 | 7 | 140 | 48 | 23 | — | 6 |
| All Diarrhœal ... | 799 | 3 | 30 | 492 | 160 | 83 | 16 | 15 |

(40) *Deaths from Diarrhœal Diseases during the Year 1928—Distribution by Wards.*

| Ward. | Diarrhœa and Enteritis. | Dysentery. | Total. |
|----------------------|-------------------------|------------|--------|
| Fort ... | — | — | — |
| Pettah ... | 4 | 4 | 8 |
| San Sebastian ... | 17 | 11 | 28 |
| St. Paul's ... | 33 | 22 | 55 |
| Kotahena ... | 54 | 12 | 66 |
| Mutwal ... | 91 | 12 | 103 |
| New Bazaar ... | 56 | 18 | 74 |
| Maradana North ... | 29 | 6 | 35 |
| Maradana South ... | 23 | 3 | 26 |
| Dematagoda ... | 37 | 16 | 53 |
| Slave Island ... | 38 | 15 | 53 |
| Kollupitiya ... | 19 | 3 | 22 |
| Cinnamon Gardens ... | 9 | — | 9 |
| Bambalapitiya ... | 15 | 1 | 16 |
| Timbirigasyaya ... | 15 | 4 | 19 |
| Wellawatta ... | 22 | 2 | 24 |
| Untraced ... | 10 | 11 | 21 |
| Port ... | — | 2 | 2 |
| Beyond limits ... | 100 | 85 | 185 |
| Total ... | 572 | 227 | 799 |

(41) *Deaths from Diarrhœal Diseases, 1928—Mortality by Months.*

| Month. | | Diarrhœa and Enteritis. | | Dysentery. | | Total. |
|-----------|-----|----------------------------|-----|------------|-----|--------|
| January | ... | 52 | ... | 13 | ... | 65 |
| February | ... | 36 | ... | 20 | ... | 56 |
| March | ... | 50 | ... | 10 | ... | 60 |
| April | ... | 38 | ... | 11 | ... | 49 |
| May | ... | 41 | ... | 12 | ... | 53 |
| June | ... | 46 | ... | 17 | ... | 63 |
| July | ... | 58 | ... | 20 | ... | 78 |
| August | ... | 41 | ... | 19 | ... | 60 |
| September | ... | 50 | ... | 21 | ... | 71 |
| October | ... | 45 | ... | 17 | ... | 92 |
| November | ... | 58 | ... | 33 | ... | 91 |
| December | ... | 57 | ... | 34 | ... | 91 |
| Total | | 572 | | 227 | | 799 |

XV.—ENTERIC FEVER.

The total number of cases reported during the year was 528, including 290 cases from outside Municipal limits and 6 port cases, thus making the actual Colombo cases (exclusive of port and outside) 230. This is the second lowest on record, the lowest being 206 cases in 1927.

The largest number of cases occurred in Dematagoda, Mutwal (Modera), Maradana North, and Maradana South, numbering 26, 24, 21, and 20, respectively, thus emphasizing the fact that enteric fever prevails where there is bad drainage. Dematagoda, Maradana North, and Maradana South are three of the congested and overcrowded Wards, where exist some of the most insanitary dwellings in the City with a very large number of dry, earth closets situated in close proximity to each other. A number of very narrow lanes cross and re-cross these 3 Wards with such regularity (or rather irregularity) that scavenging and conservancy have to be done with the greatest inconvenience.

Mutwal is notorious for having one of the worst slum areas in the City, viz., Rajamalwatta, situated right in the heart of the Ward. One part of Mutwal, particularly the northern end, looks like an isolated village with more or less the same sanitary conditions as seen in the country but with the added misfortune of occasionally getting flooded by the overflowing of the Kelani river, washing away in many cases the contents of the dry-earth closets and all foul collections of waste products. Scavenging and conservancy at such times are made well nigh impossible.

The much polluted San Sebastian canal and the effluent from the treatment works at Madampitiya both flow into the Kelani river not very far from its mouth. Unfortunately the effluent is not quite satisfactory (a matter which is now receiving the attention of the Council) and so it has been found necessary to declare this part of the river as infected. Nevertheless in spite of notices and even prosecutions very many people residing in Mutwal persistently bathe here.

Reference to the Spot Maps Nos. II. and III. show at a glance the evils of overcrowding and bad housing conditions.

It is a noteworthy fact that the great majority of enteric fever cases which occurred in Bambalapitiya and Wellawatta happened to be right along the sea on either side of the main Colombo-Galle road. (*Vide* Spot Map II.) The reason for this I believe is that it is the area where all those private lanes, with no provision for effective surface drainage, exist. The question of the proper maintenance of these lanes is yearly becoming a matter of great importance from a sanitary point of view and something should be done before much more damage is caused.

Enteric fever has been with us for so long a time that very many, especially the poor, are apt to lose sight of the fact that it is a preventable disease and prefer to look upon it as a mere evil. In a report of this nature I need only say that the greatest victories in preventive medicine have been scored in the matter of enteric fever and a good many cases can be prevented if the people would only keep in mind the three F.'s :—Food, flies, fingers; keep the flies off the food and the fingers (unwashed) off the mouth.

One of the greatest handicaps in adopting early preventive measures is the late notification of enteric fever by the general practitioners, who in the majority of cases are not to be blamed, because by the time the doctor is called in, about 8–10 days have elapsed, 2 or 3 having been spent on trying home-remedies and during the rest of the time treatment having been taken from a Vederala (Native Doctor). In these circumstances the damage done by the patient by way of infecting others in the household is already accomplished by the time preventive measures are undertaken. It would be well if the general practitioner, whose co-operation is essential to any Public Health authority, keep the above facts in view when called upon to see a case of fever and in any matter of doubt or delay make use of the services of the City Microbiologist, who is always ready to do the necessary tests free of charge. Very few medical men, I regret to state, do take advantage of this concession. The prevention of enteric fever is as much in the hands of the general practitioner as it is with any public health body.

Under the conditions prevalent in Colombo the best weapon against this disease is that of inoculation, which should be done, at the latest, as soon after exposure to infection as possible if it is not done before. This department cannot undertake to do so to any great extent because, as shown above, the notification of cases is often 10–12 days after their occurrence. If the general practitioners on being called to a case would urge upon the others living in the infected house the importance of getting inoculated a large amount of case to case infection must naturally be prevented.

In spite of all, in a city like Colombo with its large population and where enteric fever has prevailed for so long, there must be an enormous number of “carriers” who are no doubt responsible for a fair number of the cases and the danger from them is very much enhanced by the existence of so many dry-earth closets.

ENTERIC FEVER 1928
IN THE
CITY
OF
COLOMBO

Published under the orders of A. H. B. Dawson Surveyor General, Ceylon

230 Enteric ●
127 Continued Fever. ●

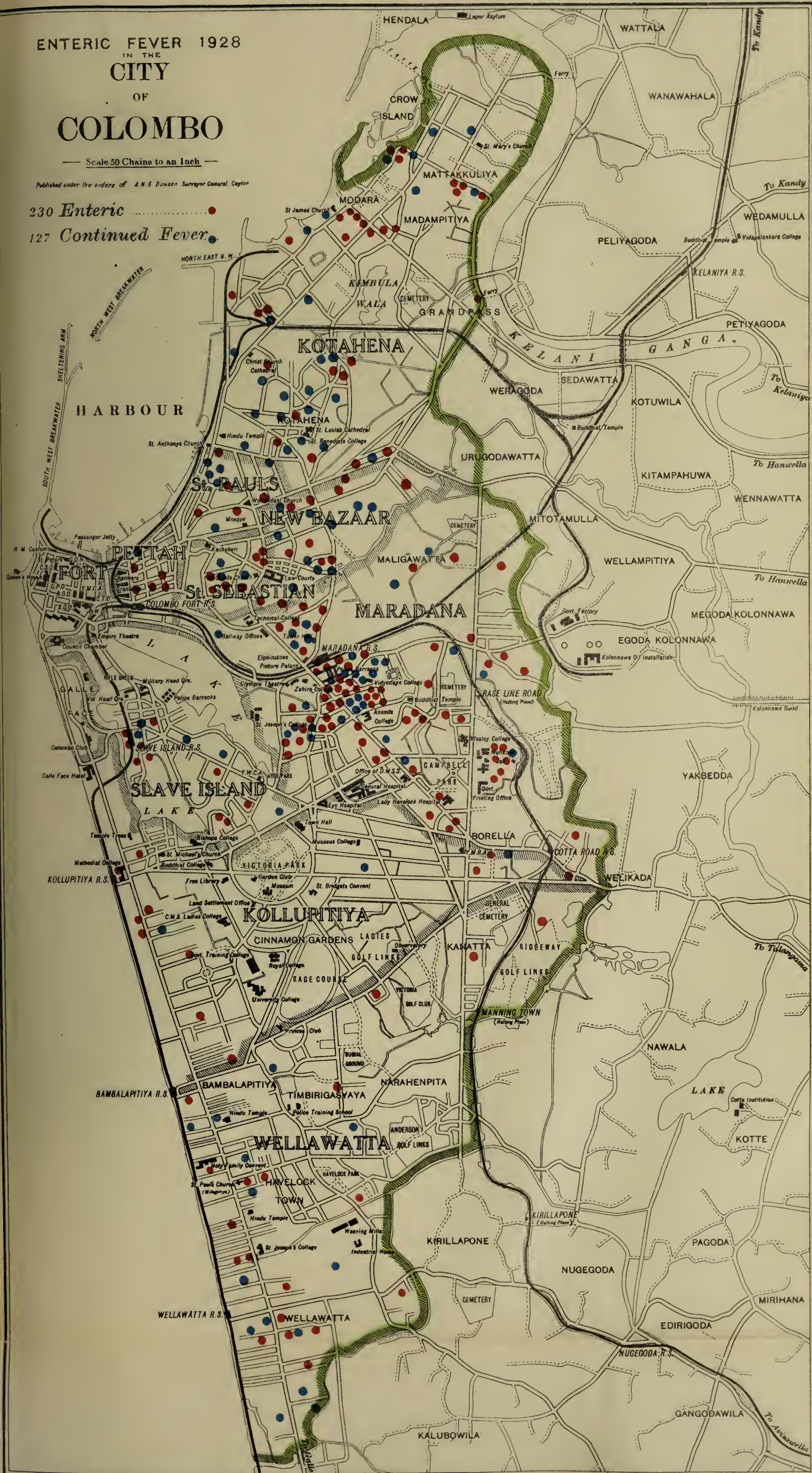
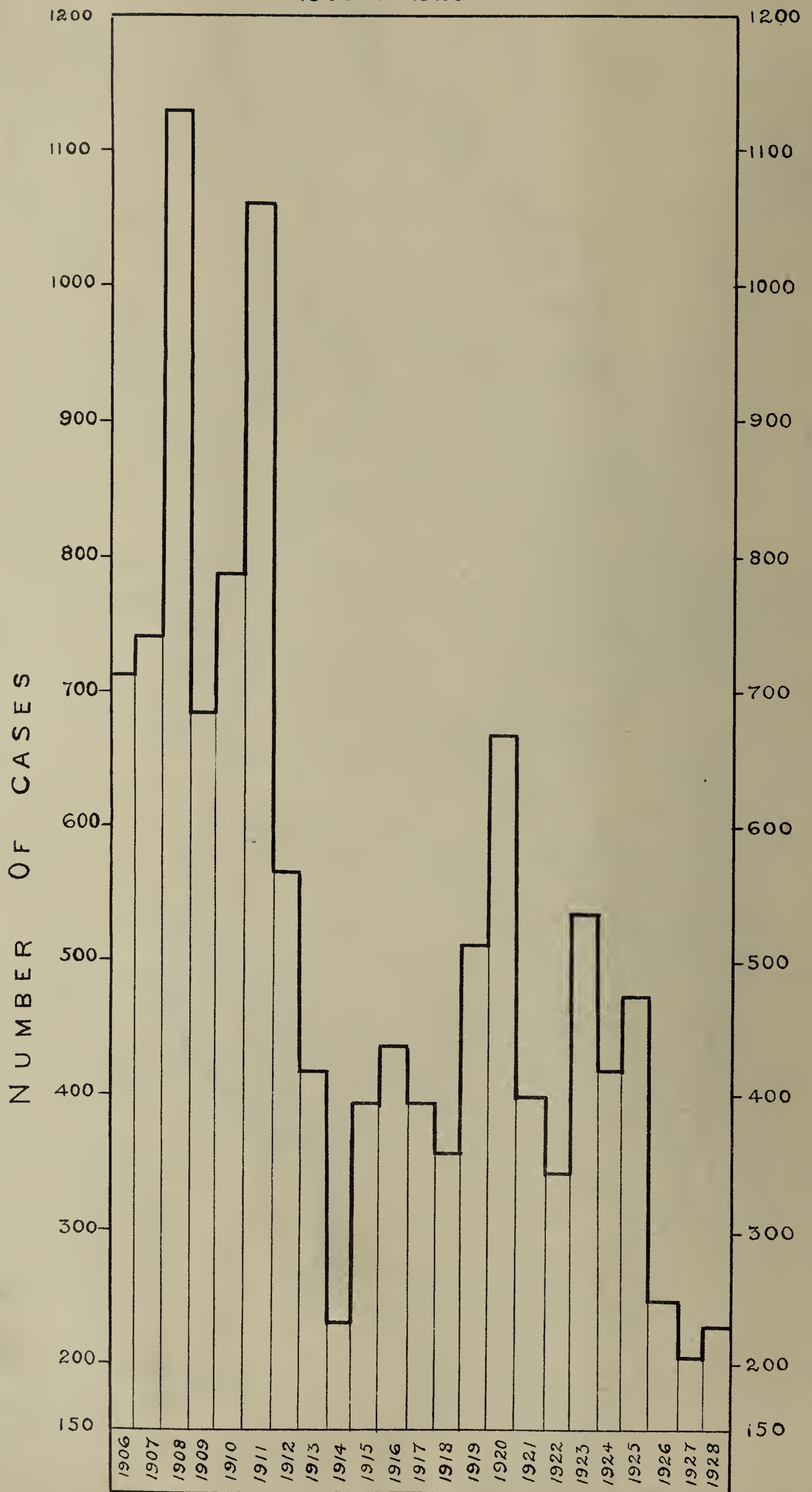




DIAGRAM N^o VI
ENTERIC FEVER (TOWN CASES ONLY)
1906 to 1928



(42) *Enteric Fever during the Year 1928 (inclusive of Port and Outside Cases).
Distribution by Race, Sex and Age. Number of Cases.*

| Race. | Sex. | 0 to 5 Years. | 5 Years to 10 Years. | 10 Years to 15 Years. | 15 Years to 20 Years. | 20 Years to 25 Years. | 25 Years to 30 Years. | 30 Years to 35 Years. | 35 Years to 40 Years. | 40 Years to 50 Years. | 50 Years to 60 Years. | 60 Years and Over. | Total. | Total of each Race. | Number of Deaths. | Case Mortality per Cent. |
|-----------|-------------------|---------------|----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|--------------------|--------|---------------------|-------------------|--------------------------|
| All Races | ... { Males ... | 4 | 17 | 31 | 45 | 78 | 53 | 39 | 35 | 23 | 8 | 1 | 334 | 526 | 140 | 26.6 |
| | ... { Females ... | 3 | 15 | 27 | 25 | 36 | 28 | 17 | 10 | 17 | 12 | 2 | 192 | | | |
| Europeans | ... { Males ... | — | — | — | 2 | — | — | — | 2 | 2 | 1 | — | 7 | 9 | — | — |
| | ... { Females ... | — | — | — | — | — | — | — | — | 2 | — | — | 2 | | | |
| Burghers | ... { Males ... | — | — | — | 3 | 5 | 1 | 2 | 2 | 2 | — | — | 15 | 26 | 7 | 26.9 |
| | ... { Females ... | — | 1 | 1 | 1 | 2 | 1 | — | — | — | 4 | 1 | 11 | | | |
| Sinhalese | ... { Males ... | 3 | 13 | 28 | 37 | 54 | 31 | 26 | 24 | 17 | 5 | — | 238 | 404 | 105 | 26.0 |
| | ... { Females ... | 2 | 13 | 26 | 21 | 31 | 25 | 16 | 10 | 14 | 7 | 1 | 166 | | | |
| Tamils | ... { Males ... | 1 | 2 | — | 2 | 7 | 5 | 3 | 1 | 1 | — | — | 22 | 28 | 10 | 35.7 |
| | ... { Females ... | — | 1 | — | — | 2 | 1 | 1 | — | 1 | — | — | 6 | | | |
| Moors | ... { Males ... | — | 1 | — | — | 3 | 1 | 2 | 2 | 1 | 1 | — | 11 | 13 | 5 | 38.5 |
| | ... { Females ... | — | — | — | — | 1 | 1 | — | — | — | — | — | 2 | | | |
| Malays | ... { Males ... | — | 1 | 1 | — | 2 | 1 | 1 | — | — | — | — | 6 | 10 | 4 | 40 |
| | ... { Females ... | 1 | — | — | 2 | — | — | — | — | — | 1 | — | 4 | | | |
| Others | ... { Males ... | — | — | 2 | 1 | 7 | 14 | 5 | 4 | — | 1 | 1 | 35 | 36 | 9 | 25 |
| | ... { Females ... | — | — | — | 1 | — | — | — | — | — | — | — | 1 | | | |

(43) *Enteric Fever and Continued Fever by Wards, 1928. Number of Cases.*

| Ward. | Enteric Fever. | Continued Fever. | Total. |
|---|----------------|------------------|--------|
| Colombo (inclusive of Port and Outside) ... | 526 | 167 | 693 |
| Colombo (exclusive of Port and Outside) ... | 230 | 127 | 357 |
| Fort ... | 2 | — | 2 |
| Pettah ... | 4 | 1 | 5 |
| San Sebastian ... | 7 | 4 | 11 |
| St. Paul's ... | 5 | 7 | 12 |
| Kotahena ... | 6 | 17 | 23 |
| Mutwal ... | 24 | 13 | 37 |
| New Bazaar ... | 11 | 13 | 24 |
| Maradana North ... | 21 | 9 | 30 |
| Maradana South ... | 20 | 10 | 30 |
| Dematagoda ... | 26 | 13 | 39 |
| Slave Island ... | 13 | 7 | 20 |
| Kollupitiya ... | 10 | 3 | 13 |
| Cinnamon Gardens ... | 3 | 2 | 5 |
| Bambalapitiya ... | 8 | 3 | 11 |
| Timbirigasyaya ... | 4 | 2 | 6 |
| Wellawatta ... | 9 | 8 | 17 |
| Vagrants and Untraced ... | 39 | 14 | 53 |
| Prisons ... | 18 | 1 | 19 |
| Port ... | 6 | 2 | 8 |
| Outside Municipal Limits ... | 290 | 38 | 328 |

(44) *Enteric Fever and Continued Fever during the Year 1928, by Race. (Inclusive of Port and Outside Cases and Deaths.)*

| | All Races. | Euro-peans. | Bur-ghers. | Sin-halese. | Tamils. | Moors. | Malays. | Others. |
|--------------------------|------------|-------------|------------|-------------|---------|--------|---------|---------|
| Enteric Fever... { Cases | 526 | 9 | 26 | 404 | 28 | 13 | 10 | 36 |
| ... { Deaths | 140 | — | 7 | 105 | 10 | 5 | 4 | 9 |
| Continued Fever { Cases | 167 | 4 | 9 | 121 | 12 | 13 | 3 | 5 |
| ... { Deaths | 52 | — | — | 37 | 8 | 6 | 1 | — |
| Total { Cases | 693 | 13 | 35 | 525 | 40 | 26 | 13 | 41 |
| ... { Deaths | 192 | — | 7 | 142 | 18 | 11 | 5 | 9 |

(45) *Enteric Fever during the Year 1928, by Race. Number of Cases.*

| Race. | (a) All Town Cases. | (b) Town Cases (exclusive of Cases Infected Outside Colombo). |
|-----------|---------------------|---|
| All Races | 230 | 226 |
| Europeans | 5 | 5 |
| Burghers | 15 | 15 |
| Sinhalese | 139 | 137 |
| Tamils | 22 | 21 |
| Moors | 13 | 13 |
| Malays | 10 | 10 |
| Others | 26 | 25 |

XVI.—CONTINUED FEVER.

167 cases of continued fever with 52 deaths were reported in 1928 as against 176 with 59 deaths in 1927, thus showing a slight diminution both in its incidence and mortality.

By referring to the Spot Map No. II. it will be seen that continued fever occurs in the same districts where enteric fever prevails, and this would naturally lead one to the belief that most of such cases are only mild attacks of enteric or para-typhoid fever. From a purely scientific basis “continued fever” conveys nothing, for it is only a symptom of a disease and not a disease itself. Therefore it is just as possible that diseases other than enteric fever may also be reported as cases of continued fever, *e.g.*, influenza, malaria, pyæmic conditions, &c., so much so that in a tropical country where various kinds of fevers exist the term “continued fever” becomes still less significant.

As mentioned in the section on enteric fever, if the general practitioners, before reporting a case as continued fever, would only take the trouble to get a Widal test done they will be doing a great service both to the patient and the community. So far as this department is concerned the blood is tested as opportunities arise, but the policy adopted is not to interfere whenever possible in any way with any patient who is under a doctor’s charge, not even to the extent of taking two or three drops of blood for purposes of examination. When removal to the Infectious Diseases Hospital is imperative the relatives’ feelings cannot always be considered, but even then the doctor in whose charge the case may be is always informed of the action intended.

The people themselves, although they do not mind the officers of this department making ordinary inquiries and attending to the drainage and general sanitary conditions without, do not at all relish the idea even of touching the patient. When a case from which a few drops of blood have been taken for a test ends fatally, it is not rare to find the people attempting to attribute this also as one of the causes of the patient’s death, especially if it had been done by one of the public health officers. These are only a few of the difficulties that public health officers have to contend with, and it is earnestly hoped that the general practitioners would realize this and spend just a little more of their valuable time to take full opportunity of the free concession granted by this department.

In all cases reported as continued fever the preventive measures taken are the same as if they were cases of enteric fever.

XVII.—PULMONARY TUBERCULOSIS.

(Phthisis pulmonalis, Consumption.)

The total number of cases reported during the year was 1,377, out of which 455 were beyond town limits and 12 were port cases, thus making the number of town cases 910 as against 810 in 1927 and 977 in 1926. The number of deaths from phthisis was 597.

By Wards, New Bazaar heads the list with 78 cases, the others with a high incidence being Dematagoda, Mutwal, Kotahena, Maradana (North and South), St. Paul’s, and San Sebastian. They are the very Wards that are overcrowded with an alarming predominance of insanitary houses, where most of the poorer classes live.

The three Wards with the lowest incidence are Cinnamon Gardens, Timbirigasyaya, and Pettah, with 8, 8, and 9 cases respectively. The two former constitute the chief residential area of the City where the richest classes reside in well appointed houses with plenty of fresh air and all sanitary amenities, so that the small number of cases is as would be expected. Curiously enough the incidence of the disease is very low in the Pettah, a Ward adjoining San Sebastian and St. Paul’s, both of which have a high incidence. It is probably due to the fact that Pettah is purely a business centre where comparatively few people live, most of those who work in this Ward residing outside, chiefly in San Sebastian or St. Paul’s.

Reference to Spot Map No. III. will show these facts in a striking manner, and taking this in conjunction with Spot Map No. II. (enteric fever) no one can gainsay the fact that the root cause of it all is overcrowding and bad housing conditions with their concomitant evils.

There are still a great many among the indigenous population who look upon phthisis as an incurable disease. It is worth while informing them that phthisis is not only curable but it is also preventable.

Tuberculous infection through the agency of the cow and its milk may be considered a rarity in this country, the cattle being particularly free from this disease here unlike in European countries. Therefore it is not incorrect to conclude that most of the cases are infected from human cases of tuberculosis and as such it would appear as if the prevention of infection would be less difficult here than in Europe. But the greatest obstacle in the way is the extreme poverty of the people. Almost all the families of the working classes entirely depend on the earnings of the breadwinner to eke out an existence. Their salaries being so small nothing can be saved, so that when the father goes down with tuberculosis the most he can do is to get a bottle of medicine from the nearest dispensary and carry on with his usual routine exposing all the rest in the house to infection.

On the other hand the indigenous races of the country have so peculiar an abhorrence of all classes of hospitals and sanatoria that they will enter them only as a last resort. Moreover, the majority of the poor, and in fact a good many of the others too, still have recourse, owing to cheapness and prejudice, to the Ayurvedic (Native) practitioner, whose methods of diagnosis and treatment of all lung conditions are notoriously far from satisfactory, so that early cases of tuberculosis are entirely missed and when a diagnosis is made it is often too late to be of any benefit to the patient. Having no knowledge of bacteriology their attempt at preventive medicine is next to nothing in addition to the difficulties in diagnosis.

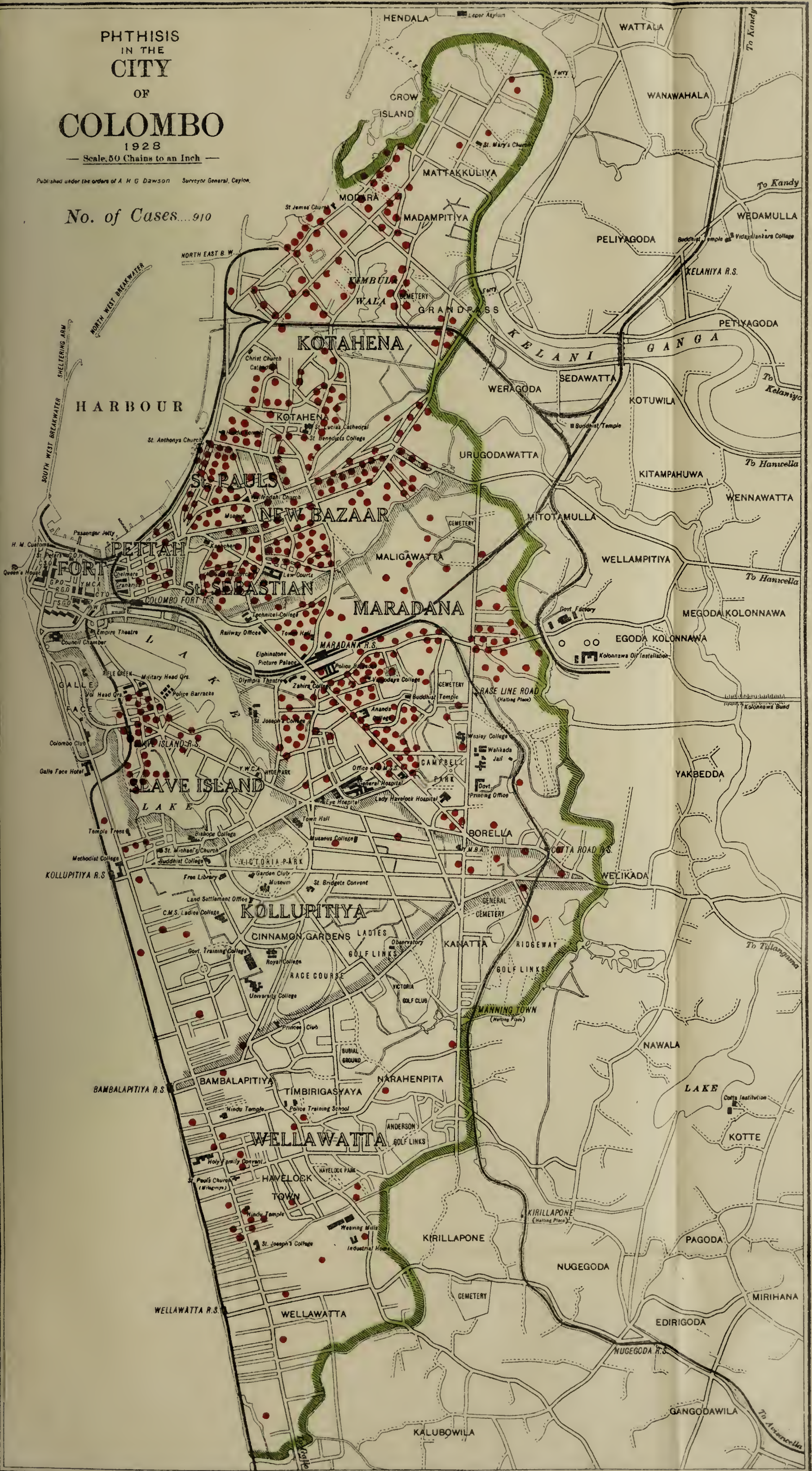
Owing to a groundless but innate prejudice born of social influences many still consider it a slur on the family to find one’s case diagnosed as tuberculosis, so much so that in order to keep up appearances it is not uncommon to find patients in the early stages of the disease carrying on their usual business and social duties in the ordinary way. Such being the mentality of the people

PHTHISIS
IN THE
CITY
OF
COLOMBO
1928

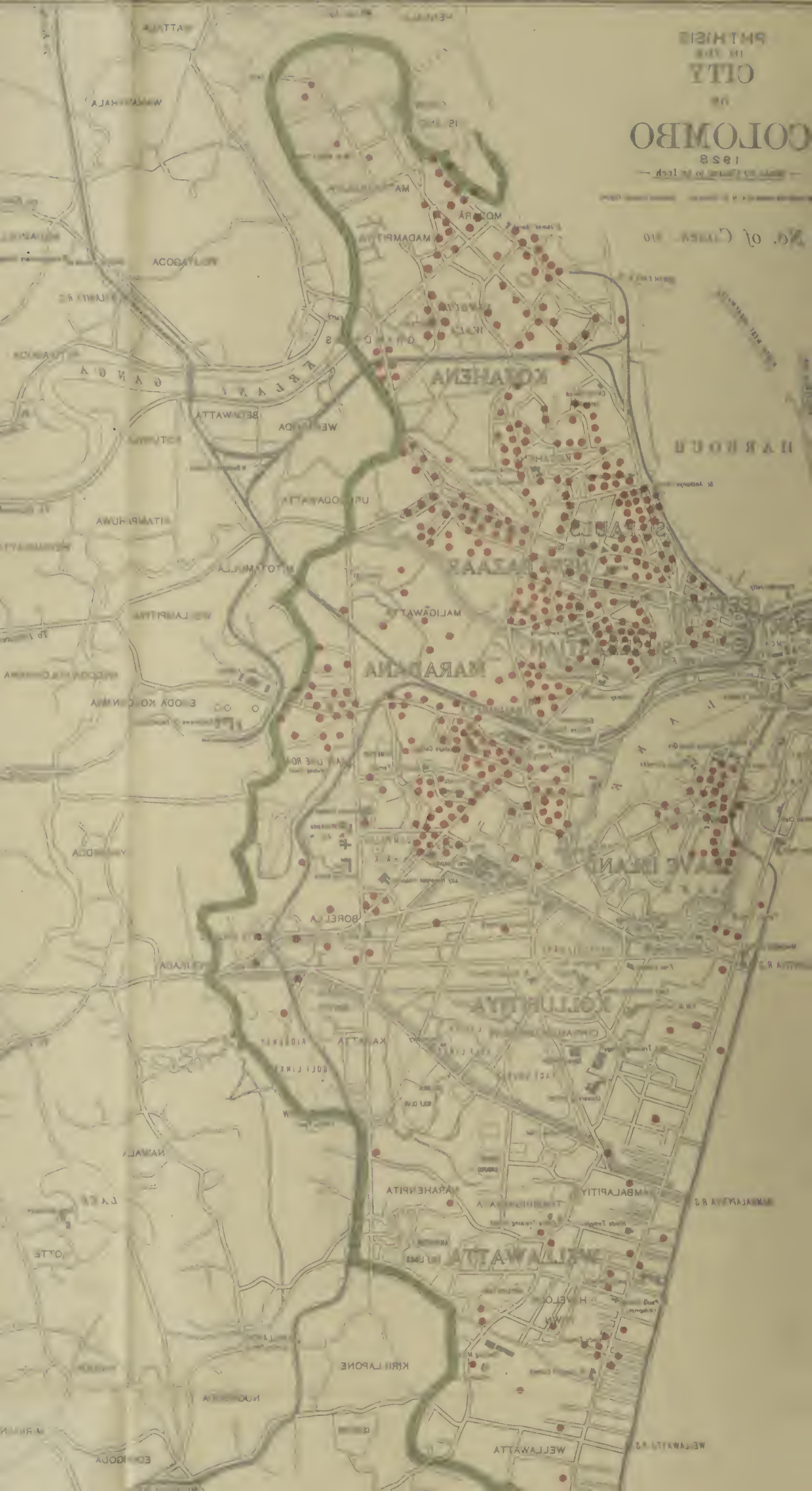
— Scale 50 Chains to an Inch —

Published under the orders of A. H. G. Dawson, Surveyor General, Ceylon.

No. of Cases... 910



SPOT MAP
CITY
1828
No. of Census 10



the only alternative possible at present, at least until education will teach them that hospitals are for their benefit and not to their detriment, is to carry treatment and advice into their houses. Opening up of free tuberculosis dispensaries in the more congested parts of the City, together with an adequate staff of tuberculosis nurses whose duties stand in the same relation as Health Visitors for Child Welfare work, is very likely to be of material benefit in checking the ravages of this social evil. These dispensaries with fully qualified Medical Officers may be run as branches of the main Anti-Tuberculosis Institute now situated in San Sebastian.

As in all other large cities tuberculosis in Colombo too is greatly a social question but it is impossible not to be struck by the grave import of the situation when we consider the abject poverty of the poorer classes living in overcrowded insanitary houses in the congested parts of the City.

(46) *Phthisis during 1928 by Race and Sex.*

| Number of Cases. | | | | | | | | | | | |
|------------------|--------|-----|----------|-----|--------|------------|--------|-----|----------|-----|--------|
| Race. | Males. | | Females. | | Total. | Race. | Males. | | Females. | | Total. |
| Europeans ... | — | ... | — | ... | — | Malays ... | 12 | ... | 14 | ... | 26 |
| Burghers ... | 18 | ... | 27 | ... | 45 | Others ... | 33 | ... | 5 | ... | 38 |
| Sinhalese ... | 249 | ... | 238 | ... | 487 | | | | | | |
| Tamils ... | 125 | ... | 88 | ... | 213 | Total ... | 494 | | 416 | | 910 |
| Moors ... | 57 | ... | 44 | ... | 101 | | | | | | |

(47) *Incidence of Phthisis during 1928, by Wards.*

| Ward. | No. of Cases. | Ward. | No. of Cases. |
|----------------------|---------------|--------------------|---------------|
| Fort ... | — | Bambalapitiya ... | 19 |
| Pettah ... | 9 | Timbirigasyaya ... | 8 |
| San Sebastian ... | 36 | Wellawatta ... | 14 |
| St. Paul's ... | 38 | Vagrants ... | 23 |
| Kotahena ... | 61 | Untraced ... | 331 |
| Mutwal ... | 67 | | |
| New Bazaar ... | 78 | Total Town ... | 910 |
| Maradana North ... | 46 | Port ... | 12 |
| Maradana South ... | 47 | Beyond Limits ... | 455 |
| Dematagoda ... | 69 | | |
| Slave Island ... | 39 | Grand Total ... | 1,377 |
| Kollupitiya ... | 17 | | |
| Cinnamon Gardens ... | 8 | | |

XVIII.—INFLUENZA.

The number of influenza cases treated during the year at the 7 Municipal Free Dispensaries is 5,388 as against 4,406 during 1927. The figures for 1928 include 123 cases treated at the Gintupitiya Dispensary which was opened in August, 1928.

From Statement 48 it will be seen that from May, the start of the south-west monsoon, the monthly number of cases was very high, persisting right through to the end of the year without the usual intermission which generally occurs between the two monsoons. Perhaps the wave of influenza that has been felt in various other countries in the world has not been without its effects on Colombo. The number of deaths due to influenza during the year is 435.

(48) *Influenza Cases reported from Municipal Dispensaries during each Month of the Year 1928.*

| | Slave Island. | St. Paul's | Maradana. | Mutwal. | New Bazaar. | Wellawatta. | Gintupitiya. | Total. |
|---------------|---------------|------------|-----------|---------|-------------|-------------|--------------|--------|
| January ... | 17 | 130 | 70 | 53 | 73 | 22 | * | 365 |
| February ... | 117 | 78 | 87 | 32 | 60 | 17 | — | 391 |
| March ... | 112 | 63 | 60 | 42 | 57 | 16 | — | 350 |
| April ... | 102 | 60 | 58 | 25 | 44 | 10 | — | 299 |
| May ... | 181 | 88 | 92 | 74 | 86 | 15 | — | 536 |
| June ... | 102 | 124 | 91 | 103 | 82 | 14 | — | 516 |
| July ... | 133 | 134 | 56 | 48 | 78 | 9 | — | 458 |
| August ... | 107 | 101 | 113 | 62 | 101 | 14 | — | 498 |
| September ... | 95 | 65 | 78 | 69 | 73 | 10 | 19 | 409 |
| October ... | 23 | 85 | 121 | 69 | 63 | 12 | 24 | 397 |
| November ... | 100 | 88 | 117 | 187 | 77 | 28 | 43 | 640 |
| December ... | 79 | 115 | 98 | 134 | 54 | 12 | 37 | 529 |
| Total ... | 1,168 | 1,131 | 1,041 | 898 | 848 | 179 | 123 | 5,388 |

XIX.—PNEUMONIA.

Pneumonia was the cause of 1,184 deaths during 1928 as against 1,003 in 1927. 14·8 per cent. of the total deaths was due to this disease, whereas among infants under one year it caused 12·4 per cent. of the deaths. The larger number of deaths amongst males may be due to greater exposure to inclement weather, overwork, fatigue, and addiction to alcohol which are all causes predisposing to this disease.

Year in and year out it is found that pneumonia causes by far the largest number of deaths, the next highest for the year under review being tubercular disease with 641, very nearly only half of that due to the former.

* The Gintupitiya Dispensary was opened on August 17, 1928.

(49) *Deaths from Penumoniam during 1928, by Race—Expressed as a Percentage of Total Number of Deaths.*

| Race. | No. of Deaths. | Percentage of Total No. of Deaths. |
|---------------|----------------|------------------------------------|
| All Races ... | 1,184 | 14'8 |
| Europeans ... | 7 | 13'7 |
| Burghers ... | 52 | 16'0 |
| Sinhalese ... | 643 | 14'3 |
| Tamils ... | 244 | 17'1 |
| Moors ... | 146 | 12'8 |
| Malays ... | 30 | 13'0 |
| Others ... | 62 | 23'4 |

(50) *Deaths from Pneumonia during 1928—Distribution by Sex.*

| Race. | Males. | Females. |
|---------------|--------|----------|
| Europeans ... | 5 | 2 |
| Burghers ... | 25 | 27 |
| Sinhalese ... | 342 | 301 |
| Tamils ... | 165 | 79 |
| Moors ... | 90 | 56 |
| Malays ... | 14 | 16 |
| Others ... | 59 | 3 |
| Total ... | 700 | 484 |

(51) *Deaths from Pneumonia during 1928—Monthly Mortality.*

| Month. | No. of Deaths. | Month. | No. of Deaths. | Month. | No. of Deaths. |
|--------------|----------------|---------------|----------------|--------------|----------------|
| January ... | 122 | June ... | 135 | November ... | 83 |
| February ... | 79 | July ... | 98 | December ... | 116 |
| March ... | 117 | August ... | 90 | | |
| April ... | 66 | September ... | 86 | Total ... | 1,184 |
| May ... | 110 | October ... | 82 | | |

XX.—FOOD-POISONING.

A food-poisoning outbreak of a serious nature occurred in late September of 1928, the total number affected being 20 with 8 deaths. Out of the 20 only 4 were residents of Colombo, and they all recovered. The first intimation received was from Avissawella on September 28, stating that the affected persons had a meal on the 24th in an eating-house at Fifth Cross street, Pettah. The delay of four days in the notification was no doubt due to the fact that home remedies were tried followed by treatment at the hands of a Vedarala who when the cases were getting too serious despatched them to the hospital, the Medical Officer reporting the cases straightaway. The vagueness of the report with its inevitable delay and the fact that there are a number of eating-houses in Fifth Cross street made the carrying out of investigations a most difficult matter. Nevertheless all the eating-houses in the street and the grocery stores were thoroughly searched. Nothing of importance was discovered.

On further inquiries from bus-touts and others who work in this area suspicion fell on a particular eating-house, and this was confirmed about ten days later by one of the Colombo residents who was treated in the General Hospital, others being too ill and residing too far out of Colombo to be able to confirm the suspicion fallen on this particular eating-house. For a few days all the cases reported were from the direction of Avissawella, which showed the possibility of the food taken being from some eating-house on the way. Similar cases reported from the other directions, viz., Kalutara and Kesbawa and Gampaha, wiped away this possibility.

Dr. Hirst, the City Microbiologist, investigated bacteriologically all material available, *e.g.*, finger blood and fæces of the workmen engaged in the process of preparing the food and that of the Colombo residents who were in hospital. Various suspicious foodstuffs and cooking utensils were also examined. As a result of these investigations and as Dr. Hirst reports "the most probable explanation of the origin of this food-poisoning outbreak is that some food served at the first meal followed by poisoning was heavily infected with a bacillus of the 'Salmonella' type and that portions of this meal left over were subsequently mingled with the meals which gave rise to subsequent ill-effects."

Other interesting facts :—

The poisonous food was partaken of for about seven days starting from the 24th, which is quite a probability, considering that foods of a pickled nature and certain dry curries prepared in a particular way can be kept even longer.

Twelve or more cases occurred among those who took their meals at this eating-house on the 24th and 25th, and out of a total number of 8 deaths, 7 occurred among these 12 cases, indicating that on the 24th and 25th a large amount of the offending food must have been consumed and as time went on the number of cases diminished with the subsequent diminution of the food.

Moreover, the 24th being the day on which a memorial was unveiled to perpetuate the memory of one of Lanka's distinguished sons, it is likely that these eating-houses did prepare food in larger quantities than usual for the people coming into the City, and consequently a good portion of this food left over must have been served out on the subsequent days.

Sixteen out of the 20 cases occurred among people outside Colombo. This, on the face of it, appears rather strange, but it is a fact that people who patronise these eating-houses near the bus stand are mainly those who travel into the City for business purposes.

This eating-house being of rather a better type than the usual ones there is little doubt that the ordinary cooly class who work in the neighbourhood do not have their meals here as a rule owing to the expense.

Part II.—Administration.

XXI.—EXPENDITURE, 1924–1928.

| HEAD OF EXPENDITURE. | 1924. | | 1925. | | 1926. | | 1927. | | 1928. | |
|-------------------------------------|--------------------|---------------------|--------------------|--------------------|--------------------|---------------------|--------------------|---------------------|---------------------|---------------------|
| | Expenditure. | | Expenditure. | | Expenditure. | | Expenditure. | | Expenditure. | |
| | Estimated. | Actual. | Estimated. | Actual. | Estimated. | Actual. | Estimated. | Actual. | Estimated. | Actual. |
| 1. Higher Staff ... | Rs. c. 45,720 0 | Rs. c. 45,420 71 | Rs. c. 52,920 0 | Rs. c. 52,420 0 | Rs. c. 61,320 0 | Rs. c. 59,537 40 | Rs. c. 52,920 0 | Rs. c. 48,819 15 | Rs. c. 50,344 82 | Rs. c. 50,344 82 |
| 2. Clerical Staff ... | 17,262 0 | 16,876 50 | 18,600 0 | 17,741 33 | 19,608 0 | 17,787 40 | 19,200 0 | 19,200 0 | 20,952 18 | 20,909 4 |
| 3. Sanitary Branch ... | 205,649 59 | 176,369 86 | 239,056 0 | 187,956 0 | 203,194 0 | 164,317 38 | 199,877 0 | 173,567 85 | 190,048 0 | 181,420 68 |
| 4. Dispensaries ... | 67,373 0 | 60,892 4 | 68,452 0 | 63,886 19 | 68,390 0 | 61,821 8 | 83,310 0 | 67,297 81 | 92,378 0 | 79,648 18 |
| 5. Enteric Hospital ... | 16,319 0 | 15,388 73 | 16,202 0 | 14,640 47 | * | — | * | — | * | — |
| 6. Markets ... | 28,805 0 | 28,168 31 | 30,690 0 | 29,320 71 | 34,046 0 | 32,887 74 | 37,076 0 | 35,632 56 | 40,397 0 | 38,509 69 |
| 7. Cemeteries ... | 18,430 0 | 17,481 10 | 18,834 0 | 17,095 40 | 23,716 0 | 22,421 87 | 24,868 0 | 23,151 92 | 25,012 0 | 22,954 20 |
| 8. Laboratory ... | 30,124 0 | 28,274 82 | 31,006 0 | 29,792 11 | 32,415 0 | 30,536 52 | 33,356 0 | 30,079 76 | 35,947 0 | 35,223 90 |
| 9. Laundries ... | 2,000 0 | 1,631 1 | 2,000 0 | 1,772 9 | 2,211 0 | 2,063 46 | 2,500 0 | 2,132 65 | 2,500 0 | 2,198 43 |
| 10. Child Welfare ... | — | — | — | — | 47,950 0 | 40,427 3 | 52,090 0 | 45,724 21 | 57,280 0 | 56,169 2 |
| 11. Health Education Propaganda ... | — | — | — | — | — | — | — | — | 2,500 0 | 1,676 18 |
| Total ... | 431,682 59 | 390,503 8 | 477,760 0 | 414,624 30 | 492,850 0 | 431,799 88 | 505,197 0 | 445,605 91 | 517,359 0 | 489,054 14 |

* In 1926 the Enteric Hospital was removed to Angoda outside Municipal Limits.

XXII.—NEW WORKS.

Bacteriological Laboratory.

- (1) Two additional windows and one door.
- (2) 200 square feet of new bench space with electric light, power, gas, and water.
- (3) A new electrical switch board.

Child Welfare Centre.

- Gintupitiya*—
- (1) Five step entrances, three with paved walks.
 - (2) Four fire extinguishers.
 - (3) Ten fan lights in the main hall.
 - (4) Washhand basin in Medical Officer's room.
 - (5) In children's bath room a porcelain sink bath and a dais.
 - (6) Garage.

Cemeteries.

- Kanatta*—
- (1) The water trough in block 5 D was shifted to block 5 C as this site was required for the erection of a War cross.
 - (2) The main avenue was planted with areca triandra palms to replace the old royal palms which were being fast destroyed by beetles.
 - (3) The general appearance of the cemetery was improved by the addition of new flower beds and plants.
- Liveramentu*—
- (1) New roads opened out.
 - (2) New blocks for burials opened up and laid out.
 - (3) Sections of jungle cleared.
- Madampitiya*—
- (1) A tenement consisting of two sleeping rooms, kitchens, and verandah, built for the use of married coolies.
 - (2) A new teakwood entrance gate erected in place of the old decayed one.

Markets.

- Bambalapitiya*—
- (1) Two new wooden pillars provided.
- St. John's*—
- (1) The backyard of the market paved.
- Wellawatta*—
- (1) Two new ice boxes.
 - (2) Drains constructed all round the vegetable stalls.
 - (3) A glazed glass window shade erected on the top of the front gate of the fish market.
 - (4) Waste preventive taps and detachable taps installed.
- Borella*—
- (1) The cattle shed at the gala converted into poultry stalls and three lights and water service provided.
- Kollupitiya*—
- (1) An additional poultry stall.
 - (2) Pork stall No. 1 vacant for a long time converted into a dry goods stall.
- Slave Island*—
- (1) A door fixed in the fish market.
 - (2) A parapet wall demolished and re-erected further back to open up the passage along the side of the market.
 - (3) Four electric lights in the fish market.
- Kachcheri Road*—
- (1) Two additional gas lights.

Laundries.

- Bloemendahl*—
- (1) A roof above the washing place completed.
 - (2) Twenty concrete posts were erected for drying linen.
- Polwatta*—
- (1) Opened in October, 1928.

Dispensaries.

- Maradana*—
- (1) The Dispensary was shifted in October, 1928, to the offices previously occupied by the Health Department at Maligakanda, a considerable improvement on the former rented houses. The Apothecary's quarters are airy, commodious, and possessing all modern conveniences.
- Gintupitiya*—
- (1) Opened in August 17, 1928; various minor improvements affected.

N.B.—These are the only two Dispensaries housed in a Municipal building, the others being in rented premises.

XXIII.—GENERAL SANITATION.

Details of the work done during the year by the Ward Inspectors are shown in Statements 52 and 53. The number of inspections done during the year is found to be considerably diminished, the figures being 110,033 in 1927 and 97,649 in 1928. There was also a slight diminution under most other headings too. This can be explained by the fact that on the average about 5 Sanitary Inspectors were detailed for smallpox duty daily for about 6 weeks early in the year. In view of the above the work of the whole sanitary staff may be considered satisfactory.

(52) Work done by the Sanitary Staff during the Year 1928.

| Nature of Work. | Fort. | | | | | | | | | | | | | | | | Total. |
|--|------------|--------------|----------------|-------------|-----------|-----------|--------------|-----------------|-----------------|-------------|---------------|--------------|-------------------|----------------|------------|-------------|------------|
| | Fort. | Pettah. | San Sebastian. | St. Paul's. | Kotahena. | Mutwal. | New Bazaar. | Maradana North. | Maradana South. | Dematagoda. | Slave Island. | Kollupitiya. | Cinnamon Gardens. | Bambalapitiya. | Timbiriya. | Wellawatta. | |
| 1. Number of inspections | 9,418 | 7,035 | 5,405 | 4,077 | 5,811 | 6,697 | 6,938 | 6,959 | 7,287 | 5,376 | 5,501 | 4,131 | 5,687 | 3,659 | 7,087 | 6,581 | 97,649 |
| 2. Number of premises where sanitary defects were found : | 108 | 249 | 125 | 330 | 120 | 158 | 221 | 224 | 224 | 319 | 168 | 224 | 49 | 82 | 122 | 116 | 2,839 |
| 3. Number of premises where sanitary defects were found : | | | | | | | | | | | | | | | | | |
| (a) Non-structural | | | | | | | | | | | | | | | | | |
| (b) Structural | 10 | 67 | 44 | 53 | 53 | 68 | 92 | 34 | 75 | 49 | 149 | 42 | 17 | 39 | 55 | 10 | 857 |
| 4. Number of premises where non-structural defects were rectified... | 57 | 125 | 109 | 223 | 111 | 137 | 200 | 130 | 119 | 264 | 125 | 169 | 38 | 61 | 131 | 62 | 2,061 |
| 5. Number of premises where minor structural defects were rectified. | 7 | 32 | 9 | 37 | 45 | 55 | 61 | 19 | 44 | 97 | 88 | 23 | 14 | 18 | 40 | 7 | 596 |
| 6. Number of buildings, other than dwellings, structurally improved. | 7 | 22 | — | 13 | — | 15 | 21 | 8 | 24 | 8 | 26 | 23 | — | — | 23 | 3 | 193 |
| 7. Number of insanitary premises scavenged by Public Health | | | | | | | | | | | | | | | | | |
| Department Cleansing Gang | 1 | 35 | 36 | 164 | 202 | 1,184 | 123 | 1,354 | 201 | 2,101 | 136 | 50 | 7 | 24 | 6 | 69 | 5,693 |
| 8. Number of dwellings disinfected | 7 | 22 | 108 | 88 | 196 | 193 | 116 | 236 | 173 | 98 | 202 | 59 | 38 | 60 | 30 | 79 | 1,705* |
| 9. Number of dwellings limewashed | 9 | 159 | 793 | 820 | 483 | 265 | 421 | 365 | 280 | 204 | 945 | 150 | 158 | 91 | 168 | 91 | 5,402 |
| 10. Number of wells filled up | — | — | — | — | 5 | — | — | 3 | — | 1 | — | 2 | 2 | — | 1 | 3 | 17 |
| 11. Number of cesspits filled up | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 12. Number of notices served under section 1, sub-section (1), of | | | | | | | | | | | | | | | | | |
| Ordinance No. 15 of 1882. (Filthy premises) | 2 | 37 | 41 | 73 | 41 | 26 | 102 | 95 | 122 | 66 | 128 | 43 | 17 | 23 | 36 | 43 | 895 |
| 13. Number of notices served under section 190 of Ordinance No. 6 | | | | | | | | | | | | | | | | | |
| of 1910. (Privy accommodation) | — | — | 1 | — | — | 14 | 2 | — | — | — | 3 | — | — | — | — | 7 | 27 |
| 14. Number of notices served under section 180 of Ordinance No. 6 | | | | | | | | | | | | | | | | | |
| of 1910. (Filling up stagnant pools, &c.) | — | — | — | — | 2 | — | — | — | — | 1 | — | 5 | — | 1 | — | 1 | 10 |
| 15. Number of notices served under section 178 of Ordinance No. 6 of | | | | | | | | | | | | | | | | | |
| 1910. (Cleansing and limewashing) | 11 | 131 | 95 | 214 | 17 | 7 | 54 | 43 | 41 | 21 | 85 | 16 | 11 | 18 | 24 | 12 | 800 |
| 16. Number of notices served under by-law 8 (1), chapter 22, Plague | | | | | | | | | | | | | | | | | |
| Regulations. (Improvements to buildings unfit for human | | | | | | | | | | | | | | | | | |
| habitation) | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 17. Number of notices served under section 38, Part I., of Plague | | | | | | | | | | | | | | | | | |
| Regulations. (Filling up wells) | — | — | — | — | — | — | — | 1 | — | 1 | — | 1 | 3 | — | 1 | — | 7 |
| 18. Number of milk samples taken under rule 5, chapter 14, Municipal | | | | | | | | | | | | | | | | | |
| by-laws | 73 | 72 | 71 | 73 | 72 | 72 | 72 | 72 | 72 | 72 | 74 | 75 | 72 | 72 | 73 | 75 | 1,163 |
| 19. Number of prosecutions | 62 | 180 | 252 | 188 | 149 | 221 | 178 | 165 | 146 | 137 | 190 | 130 | 63 | 30 | 52 | 77 | 2,220 |
| 20. Number of convictions | 61 | 161 | 246 | 167 | 129 | 166 | 152 | 160 | 131 | 124 | 162 | 104 | 56 | 30 | 43 | 64 | 1,956 |
| 21. Number of cases acquitted, withdrawn, or otherwise dealt with... | — | 9 | 5 | 9 | 14 | 46 | 18 | 2 | 15 | 17 | 11 | 22 | 6 | 2 | 2 | 4 | 182 |
| 22. Number of cases pending at end of year | 1 | 10 | 1 | 17 | 8 | 9 | 9 | 6 | 8 | 1 | 19 | 4 | 1 | — | 7 | 7 | 108 |
| 23. Amount of fines | Rs. 723'50 | Rs. 1,662'50 | Rs. 1,836 | Rs. 1,673 | Rs. 889 | Rs. 1,157 | Rs. 1,348'50 | Rs. 1,603 | Rs. 1,060 | Rs. 836 | Rs. 1,541 | Rs. 1,116 | Rs. 764'50 | Rs. 309'50 | Rs. 292'50 | Rs. 587 | Rs. 17,399 |

* For number of premises disinfected by Plague staff, *vide* statement No. 31.

(53) *Statement of Prosecutions and Convictions during the Year 1928.*

| Ordinance or By-law. | Offence. | No. of Prosecutions. | *No. of Convictions. |
|---|----------|----------------------|----------------------|
| Section 1, sub-section (1), of Ordinance No. 15 of 1862 : Filthy premises | ... | 707 | 607 |
| Section 1, sub-section (1), of Ordinance No. 15 of 1862 : Filthy cattle shed | ... | 11 | 4 |
| Section 1, sub-section (1), of Ordinance No. 15 of 1862 : Filthy dairy | ... | 37 | 41 |
| Section 1, sub-section (1), of Ordinance No. 15 of 1862 : Filthy laundry | ... | 2 | 9 |
| Section 1, sub-section (4), of Ordinance No. 15 of 1862 : Nuisance by cattle, swine, &c. | ... | 53 | 63 |
| Section 1, sub-section (9), of Ordinance No. 15 of 1862 : Selling unwholesome food | ... | 13 | 15 |
| Section 53 of Ordinance No. 1 of 1896 : Unregistered laundry | ... | 57 | 35 |
| Regulation 62 made under Section 4 of Ordinance No. 3 of 1897 : Moving about in public when suffering from infectious disease | ... | 2 | 2 |
| Regulation 89 made under Section 4 of Ordinance No. 3 of 1897 : Storing rice in unauthorized place | ... | 24 | 24 |
| By-laws made under Sections 109 (1) and 110 of Ordinance No. 6 of 1910 : Spitting in public place | ... | 3 | 3 |
| Section 178 of Ordinance No. 6 of 1910 : Failure to limewash | ... | 73 | 54 |
| Section 184 of Ordinance No. 6 of 1910 : Committing nuisance | ... | 17 | 14 |
| Section 190 of Ordinance No. 6 of 1910 : Failure to provide privy accommodation | ... | 25 | 17 |
| Section 205 of Ordinance No. 6 of 1910 : Failure to report infectious disease | ... | 16 | 15 |
| Section 212 of Ordinance No. 6 of 1910 : Unlicensed offensive trades | ... | 4 | 1 |
| Rule 29, chapter VIII., Municipal by-laws: Digging pits and wells without permission | ... | 7 | 7 |
| Rule 31, chapter VIII., Municipal by-laws : Failure to properly dispose of rubbish... | ... | 4 | 3 |
| Rule 36, chapter VIII., Municipal by-laws : Picketing cattle in Municipal laundry... | ... | 2 | 2 |
| Rule 43, chapter VIII., Municipal by-laws : Stabling in verandah | ... | 1 | — |
| Rule 4, chapter IX., Municipal by-laws : Filthy bathing place | ... | 3 | 2 |
| Rule 1, chapter XI., Municipal by-laws : Unlicensed eating-house | ... | 14 | 15 |
| Rule 7, chapter XI., Municipal by-laws : Filthy eating-house | ... | 78 | 69 |
| Rule 7, chapter XI., Municipal by-laws : Filthy bakery | ... | 24 | 23 |
| Rule 8, chapter XI., Municipal by-laws : Unclean workmen in bakery | ... | 11 | 10 |
| Rule 10, chapter XI., Municipal by-laws : Conveying bread in open basket | ... | 2 | 1 |
| Rule 23, chapter XII., Municipal by-laws : Removing meat without permit | ... | 1 | 1 |
| Rule 3, chapter XIII., Municipal by-laws : Disorderly conduct in public market... | ... | 48 | 43 |
| Rule 9, chapter XIII., Municipal by-laws : Selling fish or meat without licence | ... | 1 | — |
| Rule 10, chapter XIII., Municipal by-laws : Filthy private stall | ... | 5 | 4 |
| Rule 14, chapter XIII., Municipal by-laws : Sale of unauthorized articles in stall | ... | 4 | 5 |
| Rule 28, chapter XIII., Municipal by-laws : Throwing rubbish in market | ... | 31 | 29 |
| Rule 29, chapter XIII., Municipal by-laws : Filthy market stall | ... | 45 | 41 |
| Rule 31, chapter XIII., Municipal by-laws : Closing stall without permission | ... | 3 | — |
| Rule 34, chapter XIII., Municipal by-laws : Obstruction of passages in public markets | ... | 212 | 196 |
| Rule 39, chapter XIII., Municipal by-laws : Keeping cattle in excess of number allowed | ... | 16 | 16 |
| Rule 2A, chapter XIV., Municipal by-laws : Exposing food to dust and flies | ... | 403 | 370 |
| Rule 3, chapter XIV., Municipal by-laws : Sale of adulterated milk | ... | 133 | 102 |
| Rule 4, chapter XIV., Municipal by-laws : Selling milk deficient in fat | ... | 3 | 2 |
| Rule 5, chapter XIV., Municipal by-laws : Refusing Sanitary Inspector a sample of milk | ... | 1 | — |
| Rule 7, chapter XIV., Municipal by-laws : Unregistered milk vendor | ... | 123 | 110 |
| Rule 1, chapter XVII., Municipal by-laws : Burying in unregistered burial ground | ... | 1 | 1 |
| Total | | 2,220 | 1,956 |

XXIV.—FOOD INSPECTION.

The post of Food Inspector sanctioned recently was filled in February, 1928, by one of the senior Sanitary Inspectors, Mr. W. St. G. Blacker, who had shown right through an aptitude for this sort of work. Statement 54 (b) shows the nature and quantity of foods destroyed, as unfit for human consumption, through the exertions of this Inspector.

In addition to those foodstuffs mentioned in the statement referred to above, samples of the following articles of diet, viz., milk, aerated waters, tea, arrack, ice cream, cooking vinegar, flour, sugar, fruit syrup, tinned fish, meat and milk, and curd milk, were at various times submitted to the City Analyst and City Microbiologist for their reports and action was taken wherever necessary.

In this connection it may be mentioned that arrack was shown in many instances to contain a high percentage of copper—very much higher even than the maximum quantity allowed by the Excise Ordinance, viz., 0.25 grams per gallon. This matter was brought to the notice of Government with the hope of getting it rectified with the least possible delay.

The good work done by Mr. Blacker fully justifies the creation of the post of Food Inspector. It must be admitted, however, that there is still a great deal of work to be done which can only be performed satisfactorily by the creation of at least another such post. Reference to Statement 54 (a) shows that the Sanitary Inspectors too have done a great deal in this line.

For the want of a Food and Drugs Act Ceylon is made the dumping ground for all sorts of foodstuffs which are prohibited by legislation from being imported into other countries. The need for such an Act becomes more imperative every year with the inevitable expansion of trade, and the sooner it is passed the better it will be not only for Colombo in particular but also for the whole Island in general.

* Includes convictions obtained during 1928 on prosecutions instituted during the previous year.

FISH MARKET (OLD TYPE), ST. JOHN'S ROAD:



EXTERNAL VIEW.



INTERNAL VIEW.

(54) *Foodstuffs condemned during the Year 1928.*

(a) By Ward Inspectors.

At the Customs.

| | | | | | |
|----------|-----|-----|-----|-----|----------|
| Rice | ... | ... | ... | 6 | bags. |
| Potatoes | ... | ... | ... | 123 | cwt. |
| Dry fish | ... | ... | ... | 110 | bundles. |
| Tea | ... | ... | ... | 1 | chest. |
| Cheese | ... | ... | ... | 120 | balls. |

At the Chalmers Granaries.

| | | | | | |
|------|-----|-----|-----|-------------------|----------|
| Rice | ... | ... | ... | 445 $\frac{3}{4}$ | bushels. |
|------|-----|-----|-----|-------------------|----------|

In the Municipal Markets.

| | | | | | |
|--------|-----|-----|-----|-------------------|-----|
| Fish | ... | ... | ... | 160 $\frac{3}{4}$ | lb. |
| Meat | ... | ... | ... | 43 $\frac{1}{2}$ | lb. |
| Prawns | ... | ... | ... | 5 $\frac{1}{2}$ | lb. |

In the rest of the Town.

| | | | | | |
|----------------------|-----|-----|-----|-----|--------------------------|
| Fish | ... | ... | ... | 12 | lb. |
| Dry fish | ... | ... | ... | 36 | lb. |
| Potatoes | ... | ... | ... | 17 | tons 8 cwt. 1 qr. 17 lb. |
| Fruit and vegetables | ... | ... | ... | 3 | cwt. 8 lb. |
| Onions | ... | ... | ... | 1 | ton 9 cwt. |
| Tinned fish and meat | ... | ... | ... | 135 | tins. |
| Barley | ... | ... | ... | 26 | tins. |
| Flour | ... | ... | ... | 69 | lb. |
| Garlic | ... | ... | ... | 6 | cwt. 20 lb. |
| Shredded wheat | ... | ... | ... | 1 | case. |
| Wheat pollard | ... | ... | ... | 100 | lb. |
| Condensed milk | ... | ... | ... | 7 | cases and 32 tins. |
| Sweetmeats | ... | ... | ... | 17 | lb. |

(b) By Food Inspector.

In the Municipal Markets.

| | | | | | |
|----------------------|-----|-----|-----|-------------------|-----|
| Fish | ... | ... | ... | 934 $\frac{1}{4}$ | lb. |
| Meat | ... | ... | ... | 603 $\frac{1}{4}$ | lb. |
| Fruit and vegetables | ... | ... | ... | 510 $\frac{3}{4}$ | lb. |

In the rest of the Town.

| | | | | | |
|----------------------|-----|-----|-----|-------------------|-------------------|
| Fish | ... | ... | ... | 541 $\frac{1}{2}$ | lb. |
| Meat | ... | ... | ... | 143 $\frac{3}{4}$ | lb. |
| Fruit and vegetables | ... | ... | ... | 94 | lb. |
| Boiled eggs | ... | ... | ... | 7 $\frac{1}{4}$ | lb. |
| Curry | ... | ... | ... | 12 | dishes and 10 lb. |
| Cooked blood | ... | ... | ... | 1 | dish. |
| Stale soup | ... | ... | ... | 1 | bowl. |
| Fried food | ... | ... | ... | 4 | dishes and 4 lb. |
| Sweetmeats | ... | ... | ... | 49 $\frac{1}{2}$ | lb. |
| Cakes | ... | ... | ... | 9 | lb. |

(55) *Food Trades Inspections during the Year 1928—Number of Inspections made.*

| Ward. | Bakeries, | Dairies, | Eating-Houses. | Public Markets, |
|------------------|-----------|----------|----------------|-----------------|
| Fort | 75 | —* | 916 | —† |
| Pettah | 297 | —* | 842 | 120 |
| San Sebastian | 62 | —* | 455 | 487 |
| St. Paul's | 131 | 324 | 189 | 46 |
| Kotahena | 190 | 235 | 186 | 80 |
| Mutwal | 229 | 214 | 158 | 134 |
| New Bazaar | 186 | 336 | 189 | —† |
| Maradana North | 160 | 250 | 383 | —† |
| Maradana South | 123 | 39 | 452 | 126 |
| Demetagoda | 129 | 142 | 334 | —† |
| Slave Island | 140 | 81 | 81 | 96 |
| Kollupitiya | 170 | 262 | 189 | 145 |
| Cinnamon Gardens | 85 | 227 | 264 | 120 |
| Bambalapitiya | 129 | 161 | 166 | 111 |
| Timbirigasyaya | 65 | 353 | 195 | —† |
| Wellawatta | 205 | 315 | 236 | 125 |
| | 2,376 | 2,939 | 5,235 | 1,590 |

* No dairies in these Wards, † No public markets in these Wards,

XXV.—MARKETS.

The total number of public markets in the City now is twelve.

The Wellawatta market, a new and up-to-date one, was added in 1928 to the already existing eleven markets, bringing the modern markets up to five in number. The effect of this has been to add greatly to the convenience of the residents of this locality while at the same time helping to get rid of a series of private meat and fish stalls of doubtful sanitation.

The markets at Borella, Slave Island, Kollupitiya, and Kotahena being modern have always been kept in a very satisfactory state. Bambalapitiya, Dean's road, and Gintupitiya road markets, though not new, are fairly good. Although the three markets, St. John's, Edinburgh, and Kachcheri road, do by far the largest amount of trade they are nevertheless the most unsatisfactory.

St. John's is purely a fish market, where very good fish can be obtained but under conditions almost as adverse as the fish is good. Situated in a very crowded and busy area the market is built on two road frontages in the form of a large hall with many entrances affording easy access to its interior. Yet another great obstacle to the maintenance of order and discipline is the jealousy that exists among fish-vendors, and which in some unaccountable way surpasses that among rivals of any other trade. This peculiar mentality often leads to serious fighting and quarrelling bringing danger even to the would-be peacemakers. Large numbers of men and women, with their baskets, also come here to buy fish from the bigger vendors probably for the purpose of illicit hawking. The fish that come here is brought in large packing cases at about 9.30 A.M., having arrived by train, each vendor getting as much as 30 to 40 such cases. Owing to the lack of space and proper accommodation for storing and unpacking, they are stored and unpacked in the passages nearest their stalls. The confusion at such a time, aggravated by the large crowds that gather here for business purposes, can better be imagined than described. The passages get littered with splinters of wood, little bits of fish, sea sand, and all such accompaniments of unloading and unpacking, so much so that the Market-keeper and his coolies experience the greatest difficulty in maintaining order and cleanliness until the day is well advanced. The same scene is more or less enacted again in the evenings.

Kachcheri road market and Edinburgh market are situated within 200 yards of St. John's market and within 50 yards of each other. They are also within a few yards of the main 'bus stand. The Kachcheri road market is purely for vegetables which are brought here from the country in various ways, bullock carts, 'buses, lorries, and by basket-women, the consignments arriving till nearly mid-day. Kachcheri road itself being a narrow thoroughfare is often made almost impassable by the halting of carts for purposes of unloading. Inside the market is to be seen very nearly the same picture as at St. John's road—over-crowding, blocking of passages, petty vendors and their baskets, coolies and the buyers. Fortunately the crowd here is less troublesome and although more amenable to the principles of order, the maintenance of it in a satisfactorily clean state is well-nigh impossible owing to the enormous crowds always occupying the narrow passages. A visit to this market will at once make it clear even to a casual observer by the sight of hundreds of basket women plying their trade in the open and exposed to the hot sun, that this market is totally inadequate to deal with the large amount of trade owing to insufficient space, narrow roads, and antiquated form of structure.

The Edinburgh market deals chiefly in meat, and as pointed out in the report for 1927 the stalls are constructed of limewashed planks and exposed to the dust and dirt from two adjoining streets.

These three markets may be considered as the chief centre of distribution of the three main classes of food, fish, vegetables, meat, for they supply the ships, hotels, and practically all the other markets in the City and even the suburbs.

In view of the above and considering that very nearly the whole population of the City depends, directly or indirectly, on these three markets for their commodities, the question of building a central market with proper access and wide thoroughfares where the tradesmen and their wares of these three markets can be housed is a matter of paramount importance and sanitary urgency.

XXVI.—DAIRIES AND MILK SUPPLY.

During the year two dairies were discontinued and four new ones were registered, bringing the total up to 61 as against 59 at the end of 1927. The dairies were visited on 2,939 occasions and as a result 244 convictions were obtained against them as shown on Statement 55. The total number of samples of milk taken was 1,235.

For purpose of description the dairies in the City may be classified under three heads: good, fair, and tolerable. They fall into these three groups, not because of any defects in their construction, want of an adequate water supply, &c., for these are all insisted upon before being registered, but chiefly owing to the varying intelligence and sanitary conscience of the dairymen.

The good dairies are generally owned and managed by the better and educated classes, who do this partly from a business point of view and partly as a hobby, with the result that their dairies compare very favourably with those in any other part of the Globe. Unfortunately they are only a very few.

The second class of dairies is owned by people placed in less favourable circumstances but sufficiently well educated to understand the benefits of proper hygiene and sanitation and are run for purely business reasons.

The "tolerable" class of dairies is by far the greatest both in point of number and size. The dairy-premises are generally owned by rich landlords who merely rent them to a "dairyman," who, more often than not, does not possess a single cow but merely sublets portions of the cattle shed to various people owning a couple of cows or so. The result is that the dairyman takes no interest or pride in the place but merely tries to keep it just sufficiently clean to evade a prosecution. The milk is drawn and sold by the owners of the cows and as the reputation of the dairy is of little concern to them adulteration is fairly common. These dairies are entirely in the hands of the "Nadar" class of South India, who merely come in to the Island to carry on some sort of business and find the running of such dairies yielding a profitable return.

There is yet another class which may be called "itinerant" or "unregistered" dairies and they can only be described as "abominable." There are a large number of persons owning just one or two cows as their sole worldly possession out of which they attempt to make a living. Being too poor to house their cattle in a registered dairy they resort to grazing on open parks and spaces

MARKET (OLD TYPE), KACHCHERI ROAD :



EXTERNAL VIEW.



INTERNAL VIEW.

MODERN MARKET, COLPETTY :



EXTERNAL VIEW.



INTERNAL VIEW.

during the day and at milking time the milk is drawn into vessels, often unclean, surreptitiously to supply their customers. It is surprising to see how some people who ought to know better by virtue of their education and status patronize such illicit vendors. The cows, often underfed, are not even housed in a properly constructed shed, being exposed to all conditions of inclement whether. The milk vessels are of questionable cleanliness and the milkers themselves may be suffering from various diseases. Such matters are of little concern to those who prefer to save a few cents on each bottle of milk they buy which in the long run is very dear to them as most of the milk found to be adulterated with a very large percentage of water comes from such illicit vendors. A sharp lookout is constantly kept on these men but they manage through cunning often to escape the vigilance of our milk samplers. Action was taken some time back requesting Government to help this department by not granting permission to graze cows in open Government lands and this request was after considerable argument acceded to. Although it helped to lessen the number of such illicit vendors considerably they still have recourse to large private properties.

(56) *Dairies—Number of Convictions, 1928.*

| Offence. | | | No. of Convictions in 1927. | | No. of Convictions in 1928. | |
|------------------------------------|-----|-----|--------------------------------|-----|--------------------------------|--|
| Adulteration of milk | ... | ... | 40 | ... | 77 | |
| Excess cattle | ... | ... | 29 | ... | 16 | |
| Unclean dairy | ... | ... | 31 | ... | 41 | |
| Storing milk in unauthorized place | ... | ... | — | ... | — | |
| Selling milk without card | ... | ... | 110 | ... | 110 | |
| Unlicensed dairy | ... | ... | 1 | ... | — | |
| Total | | | 211 | | 244 | |

Quality of the Milk Supply.

It is pleasing to note that during the year the following standard for milk has been made law :—

| | | | Cow. | | Buffalo. | |
|----------------|-----|-----|------|-----|----------|--|
| Total solids | ... | ... | 12'0 | ... | 16'0 | |
| Milk fat | ... | ... | 3'5 | ... | 7'0 | |
| Solids not fat | ... | ... | 8'5 | ... | 9'0 | |

Samples numbering 1,235 were taken during the year as follows :—

| | | | | | |
|-------------------------|-----|-----|-----|-----|-------|
| Town Dairies | ... | ... | ... | ... | 965 |
| Unregistered Vendors | ... | ... | ... | ... | 142 |
| Dairies outside Colombo | ... | ... | ... | ... | 128 |
| Total | | | | | 1,235 |

There is little doubt that the standard of the milk supply of the City is poor and an attempt has been made above to show some of the causes for this unsatisfactory state of affairs. So long as a large part of the milk supply is in the hands of an uneducated class of people whose ideas of sanitation are very poor and whose sole object is profit, the progress towards an ideal milk supply must indeed be slow. Considering what a paying concern a dairy is it is rather surprising that the better educated and richer class of people have not yet thought of forming a company to run at least one really large and modern up-to-date dairy-farm on the lines, for example, of the Express Dairy Co., Ltd., of London.

The City Analyst's report, Annexure B, at the end of this report gives further particulars and the results of the analysis of samples submitted to him.

(57) *Milk Sampling during the Year, 1928.*

Statement showing the Number of Samples adulterated with Water up to 10 per Cent. and above 10 per Cent.

| Source of Samples. | Number of Samples taken. | By Ward Inspectors. | | | | | | By Food Inspector. | | | | All adulterated. | | |
|-----------------------------|--------------------------|-------------------------------|-----------------------------------|-------------------------------|-----------------------------------|--------------------------|-------------------------------|-----------------------------------|-------------------------------|-----------------------------------|--------------------------------|-------------------------------|-----------------------------------|--|
| | | 1 to 10 per Cent. Water. | | | Above 10 per Cent. Water. | | | 1 to 10 per Cent. Water. | | Above 10 per Cent. Water. | | | | |
| | | Number of Samples adulterated | Percentage of Samples adulterated | Number of Samples adulterated | Percentage of Samples adulterated | Number of Samples taken. | Number of Samples adulterated | Percentage of Samples adulterated | Number of Samples adulterated | Percentage of Samples adulterated | Total Number of Samples taken. | Number of Samples adulterated | Percentage of Samples adulterated | |
| Town dairies ... | 917 | 219 | 23·9 | 89 | 9·7 | 48 | 13 | 27·1 | 24 | 50·0 | 965 | 345 | 35·8 | |
| Unregistered vendors ... | 121 | 29 | 24·0 | 51 | 42·2 | 21 | 4 | 19·0 | 11 | 52·4 | 142 | 95 | 66·2 | |
| Dairies outside Colombo ... | 125 | 29 | 23·2 | 11 | 8·8 | 3 | 1 | 33·3 | 1 | 33·3 | 128 | 42 | 32·8 | |
| Total ... | 1,163 | 277 | 23·8 | 151 | 12·1 | 72 | 18 | 25·0 | 36 | 50·0 | 1,235 | 482 | 32·0 | |

Looking at statement 57 it will be seen that so far as the registered dairies, both in and out of Colombo, are concerned the percentage of samples adulterated with up to 10 per cent. of water is 23, a high figure. But the same dairies show an average of only about 9 per cent. of

the samples adulterated with over 10 per cent. of water. No doubt this is due to the fact of their knowledge that in many instances no prosecutions are entered when the adulteration is below 10 per cent. On the other hand samples taken from unregistered vendors show that 42 per cent. are adulterated with over 10 per cent. of water.

The above analysis is made only from the figures of the Ward Inspectors' sampling of milk, and not from those of the Food Inspector's. The latter often acts on information received and naturally his figures are bound to be higher. The Ward Inspectors' figures are probably nearer the average.

110 prosecutions, resulting in 110 convictions, were entered against unregistered dairymen during the year.

The Honorary Secretary, Colombo Ladies' League, reports that thirty-five dairies entered for the League Competition for 1928.

The chief awards were as follows :—

| | |
|----------------|---|
| | A DIVISION. |
| Challenge Cup | ... Mrs. R. Koch, Glenrose, Havelock road. |
| Gold Medal ... | ... Mr. T. Don Aron Appuhamy, 8a, Kirillapone road. |
| | B DIVISION. |
| Gold Medal ... | ... Mr. Clarence de Vos, 115, Wellawatta. |

XXVII.—BAKERIES.

Three bakeries were discontinued and two others were registered anew, making the total number at the end of 1928 to be 56.

Those involved in prosecutions numbered 21 as against 26 in the previous year, and the number of convictions obtained was 33 as against 41 in 1927 :—

| Offence. | No. of Convictions. |
|---------------------|---------------------|
| Unclean bakery ... | 23 |
| Unclean workmen ... | 10 |
| Total ... | 33 |

The 33 convictions were the result of 2,376 visits made by the Sanitary Inspectors during the year.

Unlike the dairies, the bakeries in the City are all fairly satisfactory. The owners themselves are careful to keep the premises in accordance with the requirements of this department, but whenever a prosecution was deemed necessary it was, in almost all the cases, due to the negligence or carelessness of the workmen, who are daily paid and get no share of the profits of the business. There are no bakeries in the City where kneading is done by machinery.

Together with the eating-house by-laws gazetted on October 26, 1928, new by-laws dealing with the issue of licence and regulation of bakeries were made law. With regard to taking action upon them the same procedure as in the case of eating-houses was decided upon, viz., that owing to the inconvenience likely to be caused to the owners action is to be delayed till 1930. When issuing the licences for 1929, the proprietors were informed that all bakeries must conform to the new regulations before they can be licensed for 1930. These regulations mean that the majority of bakeries will have to be structurally altered, and if this could be done without disorganizing the trade or giving the owners a further extension of time there is every reason to believe that 1930 will show a great improvement.

The Secretary of the Colombo Ladies' League (bakeries branch) in her report for 1928 made the following remarks :—

“Almost every bakery has earned more marks this year than last; but there is a great deal of room for improvement in the matter of drains and general cleanliness of the bake-houses.”

I am sure the Secretary did not mean to convey the idea that the drains and general cleanliness of the bake-houses were badly neglected and filthy, but merely that they can and ought to be kept better than they have been. That there has been a general improvement all round is evident from the fact that “almost every bakery has earned more marks this year than last,” and it may be recorded that this is largely due to the constant supervision exercised by the Sanitary Inspectors.

The chief awards of the Colombo Ladies' League were as follows :—

| | |
|-------------------------------|--|
| Challenge Cup... | ... Messrs. Perera & Son, Steuart place. |
| Second Prize—Bronze Medal ... | ... Mr. W. D. John Singho, 53, Bloemendahl road. |
| | A DIVISION. |
| Silver Medal ... | ... Mr. J. A. D. Victoria, 3, Norris road. |
| Bronze Medal ... | ... Mr. W. L. Babun Appuhamy, 11, Kollnpitiya. |
| | B DIVISION. |
| Gold Medal ... | ... Mr. M. A. J. de Mel, 276, Maradana. |
| Bronze Medal ... | ... Mr. A. P. Perera, 12, Vinstwyke road. |

A word of thanks is due to the Colombo Ladies' League, whose efforts undoubtedly tend to make the proprietors of all bakeries take a keener interests in all directions regarding their work and premises.

XXVIII.—EATING-HOUSES AND TEA BOUTIQUES.

The number of eating-houses at the end of 1927 was 594. During 1928 68 discontinued and 114 new ones were registered, bringing the total at the end of 1928 to 640.

As the following table shows, 495 prosecutions were entered and convictions were obtained in 454 instances.

| Offence. | | Prosecutions. | | Convictions. |
|---------------------------------|-----|---------------|-----|--------------|
| Exposing food to dust and flies | ... | 403 | ... | 370 |
| Filthy eating-houses | ... | 78 | ... | 69 |
| Unlicensed eating-houses | ... | 14 | ... | 15* |
| Total | ... | 495 | | 454 |

Hitherto an eating-house was defined as “any house or place where cooked rice is kept for sale,” and it was therefore not possible to include the very large number of tea boutiques, where plenty of cooked foods other than rice were sold, within the term eating-house, with the result that no supervision was able to be exercised over them except merely in matters of general cleanliness. It is gratifying to report that a new set of by-laws was made law on October 26, 1928, which among other improvements brought all tea-booths under the category of eating-houses. As a convenience to the large number of eating-house and tea boutique-keepers it was decided not to put these by-laws in to effect straightaway in 1929, but to relicense all the old eating-houses, giving them notice at the same time that they will have to conform to the new by-laws before licences are granted for 1930. The same notice is to be given to the tea boutique-keepers as well. So that in 1930 a vast improvement may be expected.

XXIX.—AERATED WATER FACTORIES.

Out of the twelve aerated water factories remaining at the end of 1927, one was discontinued during 1928. They are inspected weekly and often samples are submitted to the City Analyst for his report. Some time back it was found that a few of these factories produced an aerated water with a fairly high copper-content, and immediate action was taken by this department to have it rectified, and this was done successfully.

The City Analyst in his report makes the following comments :—

“Soda waters were examined for the presence of heavy metals. None of the thirty-eight samples were seriously contaminated. Manufacturers of aerated waters now use block tin pipes. Some of the solders used contained copper and lead, but these factories have been warned to change their solder.”

Taking every thing into consideration the eleven aerated water factories in the City may be regarded as satisfactory.

XXX.—LAUNDRIES.

(a) *Public Laundries.*

On December 1, 1928, a new Municipal laundry was opened at Polwatta in addition to the two existing at Wekanda in Slave Island and Bloemendahl road in Kotahena. It provides accommodation for 28 dhobies. This area was studded with a large number of private laundries, both registered and unregistered, in about equal numbers. Action against the unregistered laundries, though contemplated many a time, was not taken as it would have meant great hardship for the residents of the district, but it is gratifying to note that all the unregistered dhobies in that area have now taken rooms in the Municipal laundry.

These laundries provide each dhoby with two rooms, one for dirty linen and one for clean linen, and also a special tank. So far as Colombo is concerned they have been a great convenience and of great hygienic value, and it is trusted that the two extra laundries contemplated, one for the Tamil dhobies of Kotahena and Mutwal area and the other for the dhobies washing in Grandpass, will soon be accomplished facts.

(b) *Private Laundries.*

There were on the register at the end of the year 279 private laundries. Out of the 301 remaining at the end of 1927, 52 were discontinued and 30 were registered anew. Owing to the class of men doing this work, private laundries at their best require a good deal of supervision and attention. One of the minimum requirements necessary before registration is the provision of two rooms for storing dirty linen and clean linen, respectively, apart from the living rooms ; but there is no guarantee whatever that either one or both of these rooms provided for linen is not used during the night for sleeping in. The private laundries in Grandpass are in this respect quite unsatisfactory. But any stringent measures taken against them might, as has happened before, end in a strike and much hardship to the people, resulting in a greater evil than the one that was to be averted. This state of affairs can be improved only by providing these areas with Municipal laundries, and viewing it in this light the provision of the two laundries referred to above may be considered a matter of prime importance and almost of sanitary urgency.

XXXI.—SCAVENGING AND CONSERVANCY.

Although this is a branch that is entirely managed and controlled by the Municipal Engineer, no apology is required for making a few observations about it in an annual report of the Public Health Department. The eulogy and comments of tourists and visitors to the City bear ample testimony to the excellent way in which the Municipal Engineer tackles this matter in spite of many a difficulty. The responsibility of keeping the private premises in a clean and sanitary state lies with the officers of the Public Health Department.

The City is provided at present with only one destructor, situated in Prince of Wales avenue at its northern end, which is capable of dealing with 60 tons of dry refuse per day when working under the most favourable conditions. The refuse from the north of the City is dealt with by this destructor, the clinker and ash being used to fill up that large unhealthy swamp lying between Prince of Wales avenue and Bloemendahl road. This marsh also serves as a dumping ground for the refuse that is left unburnt during wet weather, but when such action is necessary care is taken to cover it up daily with at least 6 inches of earth to minimise as far as practicable the breeding of flies. In spite of all the disadvantages of such dumping there is at least one advantage as well. A most unhealthy marsh, a typical breeding ground for mosquitoes, is being slowly

* One of the convictions for unlicensed eating-houses was obtained early in 1928 on a case instituted in 1927.

but surely filled up and will make an excellent park in the future. As a matter of fact a part of this made land is already being used as a playground for children, a much needed resort, lying as it does so close to those congested parts, St. Paul's and New Bazaar.

The refuse from the southern half of the City is at present dumped well outside the Municipal limits. It is gratifying, however, to be in a position to report that the Council has sanctioned the purchase of another destructor to be installed in the South. This has been an urgent necessity for a long time past, and no doubt a good many of the difficulties of scavenging will be overcome. Nevertheless, considering the size and population of the City, this cannot be considered as entirely satisfactory, for a third destructor to deal with the refuse of the central part of the City, viz., Maradana, Dematagoda, &c., is needed as much as the second one that has just been sanctioned.

Some time back the refuse used to be collected in open carts drawn by bullocks, but this very slow, noisome, and inadequate means of transport is gradually being got rid of by the introduction of specially constructed motor lorries. The first of these was introduced in 1927 and now there are altogether eight in use. It is expected that the remaining carts will also soon be a thing of the past.

Conservancy.

Since many of the streets are still without sewers a good many lavatories are of the dry earth type. Till quite recently this night-soil used to be conveyed in carts and buried in trenches. This abominable nuisance is now no more. Instead, the contents are conveyed in specially designed carts to tipping depôts which are scattered in various convenient spots and are connected to the soil sewer. With an abundant water supply and a generous use of deodorants these tipping depôts can be made to cause much less of a nuisance than one would imagine.

The importance of sewerage every street in Colombo with such a large population, in as short a time as possible, does not require much stressing. Every citizen realizes it and with the prevalence of enteric fever and the almost inevitable fly in the tropics, the existence of so many dry-earth closets must always remain a source of grave anxiety, particularly to those who are most concerned in public health.

XXXII.—MOSQUITO PREVENTION.

The mosquito prevention staff consists of one Sub-Sanitary Inspector, six Overseers, and twelve coolies. Reference to (3) of Statement 58 will show the great deal of work under all heads done during the year. The number of breeding places found, actual and potential, is larger than that of the previous year, indicating the result of the increment in the work. One pleasing factor is that the number of tenements inspected is 2,805 as against 366 in the previous year, proving that the comfort of the poor has not been neglected.

The number of complaints, however, has been increasing year by year, in 1927 the number being 270 while in 1928 it was 456. Considering that each complaint's premises has to be visited on two or three occasions after the original investigation to find out the effect of the anti-mosquito measures taken, the amount of work thrown on this small staff is becoming unwieldy. In a very large percentage of the complaints the investigations showed that the complainant's own premises is full of actual breeding places, the commonest being the gutters, innocent-looking coconut shells, tins, &c. In a few cases even the flower vases in the drawing or dining rooms were found teeming with mosquito-larvæ. With a large number of complaints, particularly during and after the rains, the most that can be done is to give temporary relief and point out the nature of the breeding places found with the hope that they will be seen to in the future. Although the complainants themselves are in many cases responsible for the discomfort they undergo, the average person is apt to lay the blame on anyone else but himself. If householders will only realize that in a country like Ceylon, any collection of water, be it ever so small, is a suitable place for mosquito breeding and action is taken to see that such useless articles as empty tins, coconut shells, motor tyres, &c., are properly disposed of, they can help themselves, their neighbours, and this department a great deal. The collections of water in unevenly laid gutters is the commonest place where prolific breeding of mosquitoes occurs, and the best way to prevent it is by drilling tiny holes about $\frac{1}{4}$ inch in diameter at regular intervals of about 18 inches.

The large marshes in Dematagoda, Maradana, St. Paul's, Kotahena, and Mutwal are typical examples of fine mosquito breeding grounds, and it is regrettable that owing to their vastness nothing can be effectively done by the small staff to relieve the residents of these parts from mosquito trouble.

In Wellawatta too this nuisance is assuming large proportions, chiefly owing to the unsatisfactory state of the private lanes, where the waste water from most of the houses finds its way into low-lying patches and stagnates there for the want of proper surface drainage. There are many such stagnations now, and during the rains their volume is enormously increased. Further, Mutwal and Wellawatta are both blessed with a good number of abandoned metal quarries belonging to private owners; but the cost of filling any of these will amount to such a prohibitive figure that action would only mean dire hardship to the owners and even utter ruin to some.

(58) *Anti-Mosquito Work, 1928.*

(1) Complaints from Householders.

| | | | |
|---|-----|-----|--------|
| Number of complaints received | ... | ... | 456 |
| Number of premises visited | ... | ... | 2,544 |
| Number of potential breeding places found | ... | ... | 48,102 |
| Number of actual breeding places found | ... | ... | 7,771 |

(2) General Inspection Work.

| | | | |
|---|-----|-----|--------|
| Number of premises visited | ... | ... | 2,949 |
| Number of tenements visited | ... | ... | 2,805 |
| Number of potential breeding places found | ... | ... | 49,834 |
| Number of actual breeding places found | ... | ... | 2,921 |

(3) Summary.

| | | | |
|---|-----|-----|--------|
| Number of complaints received | ... | ... | 456 |
| Number of premises inspected | ... | ... | 5,493 |
| Number of tenements inspected | ... | ... | 2,805 |
| Number of potential breeding places found | ... | ... | 97,936 |
| Number of actual breeding places found | ... | ... | 10,692 |

XXXIII.—DISINFECTING AND CLEANSING.

(59) (a) *Disinfecting and Cleansing.*

| | 1927. | | 1928. |
|--|--------|-----|--------|
| (a) Number of van loads of clothing, &c., disinfected... | 145 | ... | 153 |
| (b) Number of articles included in above | 3,179 | ... | 3,082 |
| (c) Number of premises cleaned up by Municipal cleansing gang | ... | ... | ... |
| (d) Number of dwellings disinfected | 5,934 | ... | 5,693 |
| (e) Number of dwellings pesterined | 7,677 | ... | 9,233 |
| (f) Number of dwellings claytonized | 7,845 | ... | 9,344 |
| (g) Number of dwellings unroofed | 14,507 | ... | 16,885 |
| (h) Number of limewashing notices served | 14,507 | ... | 16,885 |
| (i) Number of dwellings limewashed by owners or dwellers | 858 | ... | 800 |
| | 8,389 | ... | 5,409 |

From the above it will be seen that more work has been done under all the heads above with the exception of (c), (h), and (i). The extra work done under (d), (e), (f), and (g) is particularly gratifying to note.

XXXIV.—HOUSING.

Reference to Statements 60 and 61 shows that the excellent work Mr. Horan started upon on his assumption of duties as Inspector of Insanitary Buildings has been carried on during 1928 in the same efficient and tactful way. The total number of premises improved were 42 affecting 718 tenements and distributed among the following Wards:—

| | Premises. |
|---------------|-----------|
| St. Paul's | 16 |
| Pettah | 2 |
| San Sebastian | 9 |
| Slave Island | 9 |
| Kollupitiya | 3 |
| New Bazaar | 3 |
| Total | 42 |

If on the above question I do not write with the same vehemence and at same length as the Medical Officer of Health had done in his report for 1927, it is not because the sad conditions under which the poor and the working classes live have in any way appreciably improved, but merely to prevent recapitulation of what has been written before. Although in isolated blocks of tenements the conditions may have improved as a matter of course, generally I regret to say the same state of affairs is still to be seen and felt. In the last report it was shown what large employers of labour like the Government, Municipality, and business firms can and ought to do, from at least a humanitarian point of view, to alleviate the sufferings and disease—the inevitable lot of dwellers in insanitary houses.

The majority of the poor now, in the absence of proper housing from the hands of these large employers of labour, live in tenements belonging to private landowners. These owners are all well-to-do rich people who, in order to prevent the trouble of having to collect the rents monthly in small amounts from each tenant individually, lease out whole blocks of tenements to one man. Once the middleman arrives on the scene the already hard lot of the tenement dwellers is made intolerable. He in his turn, from a business point of view, soon raises the rents, so much so that the tenants being unable to pay are forced either to leave the place or find some means of sharing the rent. The former they will not do as their working places are often close by. The poor man though without money is not without initiative. He at once invites another to share his tenement, each of the two families thus having one room. Moreover, the two families now find that though their rents have been raised they actually pay less than before. By this process overcrowding with all its attendant ills reaches its maximum in these already congested parts of the City (*vide* Spot Map No. III.).

Improvement of very bad blocks of insanitary buildings must of necessity lead to a diminution in the number of available tenements in a block after its improvement because a few must always be demolished and removed for the purpose of providing adequate lighting and ventilation. Such cases too lead to overcrowding, for in addition to the diminution in the number of tenements the landlord naturally raises his rents after the improvements.

It should not be forgotten that when two or more families are compelled by circumstances to live in one tenement it is not without its ill-effects on the morality of the dwellers therein. Action against overcrowding of tenements can be taken on Chapter XV. of the Council's by-laws, but to what purpose? This will only mean the driving of a large number of the poor into the streets, thus making their plight worse than ever.

What is even more essential than the actual improvement of insanitary tenements is the provision of more houses. The slum dweller himself is the first to admit that a house at a much cheaper rent can be obtained at some distance from these congested areas, but he prefers to live near his working place in order to save the money he would otherwise have to spend on travelling. The maximum benefit of the improvement of insanitary buildings can be derived only when they are supplemented by the provision of more houses by those large employers of labour.

It may be just as well to consider the practical means of solving this acute question. The few points mentioned below are not the only means of accomplishing this but they may be considered together with the suggestions made by Dr. C. V. Aserappa, the Medical Officer of Health, in his report for 1927.

1. The Government should be prepared to offer Workmen's Railway Season Tickets at the cheapest rates possible, together with a more frequent train service both in the morning and evening to enable the labourers to get to and from work with little inconvenience.
2. Housing Schemes undertaken should be in less congested parts of the City near the outskirts and if necessary even outside the Municipal limits where land is cheaper but within easy reach of railway stations.
3. Tenement properties should be taxed lightly so as to enable the investors to get a suitable return on their investments without having the necessity to raise the rents and to encourage vacant lands that could be built upon to be made use of for this purpose.

All those who are considering the question of investing in tenement-building might with advantage bear in mind the following minimum requirements of a properly constructed sanitary block of tenements :—

1. Adequate water supply, baths and lavatories.
2. Proper sleeping accommodation.
3. Separate kitchen with a suitable smoke-vent and shelves for storage of food.
4. Cement-paving of the compound and sloping it to a properly constructed open drain so that the immediate surroundings can be satisfactorily flushed at frequent intervals.

So far as the Municipality is concerned it is gratifying to note that for 1929 a sum of Rs. 100,000 has been voted for housing its labour, this sum being in addition to what is required for the improvement of the Kochchikadde Slum Area. This augurs well for the future, and it is hoped that Government and other large employers of labour as well will not be too long in doing more than their best to combat this menace to society and public health.

(60) *List of Premises improved during 1928—By Wards.*

St. Paul's Ward.

Premises No. 4, Brassfounder street.
Premises No. 16, Brassfounder street.
Premises No. 28, Brassfounder street.
Premises No. 34, Brassfounder street.
Premises No. 19, Brassfounder street.
Premises No. 77, Chekku street.
Premises No. 101, Chekku street.
Premises No. 72, Chekku street.
Premises No. 42, Gintupitiya street,
Premises No. 27-29, Gintupitiya street.
Premises No. 26, Gintupitiya street.
Premises No. 30-30a, Gintupitiya street.
Premises No. 113, Sea street.
Premises No. 128, Sea street.
Premises No. 9, Sea street.
Premises No. 31-38, Siripina lane.

Pettah Ward.

Premises No. 15, Mitcho's lane.
Premises No. 5-6, II Fisher's lane.

New Bazaar Ward.

Premises No. 51, Silversmith street.
Premises No. 55, Ferry street.
Premises No. 55a, Ferry street.

San Sebastian Ward.

Premises No. 19, Dias place.
Premises No. 16, Dias place.
Premises No. 18, Dias place.
Premises No. 42-43, San Sebastian street.
Premises No. 20, Peer Saibo's lane.
Premises No. 6, Peer Saibo's lane.
Premises No. 18, Akbar's lane.
Premises No. 98, New Moor street.
Premises No. 56, Dam street.

Slave Island Ward.

Premises No. 74-76, Short's road.
Premises No. 28-34, Short's road.
Premises No. 46-60, Vauxhall street.
Premises No. 76-80, Vauxhall street.
Premises No. 12-20, Ferry lane.
Premises No. 88, Malay street.
Premises No. 28-34, Union place.
Premises No. 36-40, Union place.
Premises No. 1, Kew lane.

Kollupitiya Ward.

Premises No. 21, St. Michael's road.
Premises No. 22, St. Michael's road.
Premises No. 77, Kollupitiya lane.

(61) *Statement of Work done by the Inspector of Insanitary Buildings for the Year 1928.*

| | First Quarter. | Second Quarter. | Third Quarter. | Fourth Quarter. | Total for the Year. |
|--|-------------------|--------------------|-------------------|--------------------|------------------------|
| 1. Number of plans called for from Municipal Engineer | 34 ... | 21 ... | 3 ... | 34 ... | 92 |
| 2. Number of plans received | 11 ... | 8 ... | 7 ... | 12 ... | 38 |
| 3. Number of applications for "closing order" | 18 ... | 4 ... | 8 ... | 31 ... | 61 |
| 4. Number of "closing orders" issued | 18 ... | 3 ... | 1 ... | 28 ... | 50 |
| 5. Number of applications for "closing order" struck off, laid by, withdrawn, &c. | 2 ... | — ... | 1 ... | — ... | 3 |
| 6. Number of applications for "closing order" pending | 4 ... | 2 ... | 9 ... | 11 ... | 26 |
| 7. Number of closing notices affixed on buildings | 292 ... | 383 ... | 10 ... | 264 ... | 949 |
| 8. Number of premises vacated after "closing order" | 1 ... | 1 ... | 1 ... | — ... | 3 |
| 9. Number of tenements vacated under 8 above | 11 ... | 15 ... | 11 ... | — ... | 37 |
| 10. Number of persons dishoused | 28 ... | 51 ... | 49 ... | — ... | 128 |



BEFORE IMPROVEMENTS.



AFTER IMPROVEMENTS.



BEFORE IMPROVEMENTS.



AFTER IMPROVEMENTS.

(61) *Statement of Work done by the Inspector of Insanitary Buildings for the Year 1928.*—contd.

| | First Quarter. | Second Quarter. | Third Quarter. | Fourth Quarter. | Total for the Year. |
|--|-------------------|--------------------|-------------------|--------------------|------------------------|
| 11. Number of premises improved ... | 14 ... | 10 ... | 7 ... | 11 ... | 42 |
| (a) Number of tenements in (11) ... | 221 ... | 158 ... | 117 ... | 222 ... | 718 |
| (b) Number of rooms demolished in (11) ... | 59 ... | 56 ... | 65 ... | 56 ... | 236 |
| (c) Number of persons dishoused in (11) ... | 71 ... | 77 ... | 103 ... | 48 ... | 299 |
| (d) Number of new doors provided in (11) ... | 29 ... | 49 ... | 5 ... | 10 ... | 93 |
| (e) Number of new windows provided in (11) ... | 94 ... | 102 ... | 34 ... | 113 ... | 343 |
| (f) Number of doors enlarged in (11) ... | 91 ... | 55 ... | 60 ... | 151 ... | 357 |
| (g) Number of windows enlarged in (11) ... | 42 ... | 13 ... | 37 ... | 72 ... | 164 |
| (h) Number of rooms cemented in (11) ... | 267 ... | 231 ... | 130 ... | 360 ... | 988 |
| (i) Number of masonry partitions removed in (11) ... | 20 ... | 27 ... | 13 ... | 3 ... | 63 |
| (j) Number of plank partitions removed in (11) ... | 4 ... | 2 ... | 17 ... | — ... | 23 |
| (k) Number of gunny partitions removed in (11) ... | — ... | — ... | — ... | — ... | — |
| (l) Number of rooms in which masonry walls have been replaced by trellis in (11) ... | 86 ... | 72 ... | 57 ... | 129 ... | 344 |
| (m) Space unroofed square feet in (11) ... | 334 ... | 839 ... | — ... | 138 ... | 1,311 |
| (n) Length of roof raised (in feet) ... | 981 ... | 784 ... | 1,275 ... | 2,031 ... | 5,071 |

XXXV.—MUNICIPAL FREE DISPENSARIES.

The total number of Municipal Free Dispensaries is now seven.

On August 17, 1928, a new dispensary exclusively for women and children was opened in Gintupitiya. It is attached to the War Memorial Child Welfare Centre. This was the only dispensary housed in a Municipal-owned building until the Maradana Dispensary was shifted to the vacant offices at Maligakanda. It was hoped to have a lady doctor in charge of this dispensary, but owing to their scarcity a male doctor's services had to be requisitioned. That its establishment has been of material benefit to the people will be apparent from the statement of work given below.

The other six dispensaries too have done excellent work during the year, which should be a source of pride to the Medical Officers in charge and a matter of gratification to the public. The Council has sanctioned the building of its own premises for the dispensaries so as to fit them with all the amenities necessary for their work, and it is hoped that special accommodation at each of these dispensaries will also be provided for the Medical Officer, Child Welfare, to hold ante-natal clinics, &c., thus making them nuclei for additional Maternity and Child Welfare Centres.

There are many who consider that the nature of work done at these free dispensaries is beyond the scope of a health authority. The actual curing of diseases should be left in the hands of practising medical men, they say. It is stated that the Public Health Department is merely entering into unfair competition with the private practitioners in those localities where the dispensaries are situated. The answer to this is best supplied by quoting what Sir Arthur Newsholme has stated in one of his lectures.

“Public health authorities have no desire to undertake the responsibilities of medical treatment. In fact, they may be said to desire to keep this, so far as is possible, in the hands of private medical practitioners. But two facts are notorious. At least a third of the population has no regular family doctor, and even if they had one, cannot pay (individually and in isolation) the fees necessary to secure the attendance which in the public interest is peremptorily needed. This applies increasingly as medical practice becomes more complete and complex, and the necessity for frequent co-operation of one doctor with another in a given case of illness is more and more realized. Public health authorities will fail in their duty to the community if they do not act on the principle that preventive medicine is not merely concerned with (a) the prevention of preventable diseases, but is also concerned with (b) the treatment of disease in its earlier stages, and through this the prevention of the more serious later consequences of neglect.”

(62) *Work done at the Municipal Dispensaries during 1928.*

| | (a) Slave Island Dispensary. | (b) St. Paul's Dispensary. | (c) Maradana Dispensary. | (d) Modera Dispensary. | (e) New Bazaar Dispensary. | (f) Wellawatta Dispensary. | (g) San Sebastian Dispensary, from August 17, 1928. |
|--|---------------------------------|-------------------------------|-----------------------------|---------------------------|-------------------------------|-------------------------------|---|
| Number of patients treated ... | 15,392 ... | 10,563 ... | 14,380 ... | 13,539 ... | 10,034 ... | 7,219 ... | 2,601 |
| Number of visits by patients ... | 27,659 ... | 14,742 ... | 25,723 ... | 23,773 ... | 19,676 ... | 15,469 ... | 5,491 |
| Daily average attendance ... | 95 ... | 46 ... | 83 ... | 76 ... | 63 ... | 49 ... | 47 |
| Number of outdoor visits paid by the Medical Officer ... | 102 ... | 48 ... | 104 ... | 105 ... | 11 ... | 50 ... | 23 |
| Number of cases sent in by Health Visitors' tickets ... | 78 ... | — ... | — ... | — ... | 8 ... | 59 ... | 19 |
| Number of labour cases in which medical or surgical aid was rendered ... | — ... | — ... | — ... | — ... | — ... | 1 ... | 1 |
| Number of Municipal employees treated ... | 101 ... | 74 ... | 49 ... | 15 ... | 111 ... | 145 ... | 7 |
| Number of subjects inoculated against typhoid ... | 2 ... | — ... | — ... | — ... | 18 ... | 1 ... | — |

XXXVI.—CHILD WELFARE.

The first attempt at any sort of Child Welfare work undertaken by the Public Health Department was in 1905 when 6 Midwives were appointed, one more being added later. The next step was the appointment of one Health Visitor in 1912. The number of Health Visitors was gradually increased so that at the end of 1924 there were 11 Health Visitors and 7 Midwives on the staff. None of the Health Visitors had had at the time of their appointment any training in their work but most of them had either some experience in general nursing or maternity work. While getting them to do their allotted duties the department had to undertake their training as well.

Up to this time (1924) their duties were confined to house to house visiting in the slums advising, as best they could, the poor on matters of general sanitation and giving tickets for attendance at the dispensaries to those who required medical treatment. They were under the supervision of the Medical Officers of the various Municipal Dispensaries to which they were attached. The Midwives, who were also attached to the dispensaries, merely attended free of charge any case of labour among the poor who cared to ask for their services.

This state of things went on till 1925, when the Council decided to appoint a Lady Assistant Medical Officer of Health for Maternity and Child Welfare work specifically. This may be taken as the starting point in actual Maternity and Child Welfare work undertaken in real earnestness. Dr. (Mrs.) Rowlands was appointed to this post in February, 1925, and did a great amount of useful work but unfortunately resigned her post in March 1927. In August, 1927, Dr. (Mrs.) Barclay filled the vacancy but she too resigned in October, 1928, from which date one of the Medical Officers of the dispensaries took over the work temporarily until the breach is filled permanently by a lady doctor, for which applications already received are under consideration. During Dr. Barclay's tenure of office the Gintupitiya War Memorial Child Welfare Centre was opened in May, 1928.

The staff now consists of 1 Matron, 17 Health Visitors, and 12 Midwives, of which 8 Health Visitors and 7 Midwives are attached to the Centre while 9 Health Visitors and 5 Midwives are attached to the Slave Island, Maradana, Modera, and Wellawatta Dispensaries, at each of which weekly clinics for pregnant mothers and babies are held by the Medical Officer (Child Welfare).

From the short history of the Child Welfare work, undertaken by this department, given above it will be seen that this branch of the service has been very unfortunate and the progress of the work has been rudely checked on two occasions at least. Nevertheless, it is hoped that with the appointment of the new Medical Officer in charge of Maternity and Child Welfare this most important work will be carried on with no further obstacles.

One of the main features of the work of the Health Visitors as arranged now is the organization of a system whereby every baby, during the first year of its existence, is paid a visit at least once a fortnight by the Health Visitor in whose ward the baby lives.

A second Child Welfare Centre has just been built in Maligakanda and this will be opened soon on the assumption of duties by the new Medical Officer in charge of Maternity and Child Welfare. This Centre will then serve Maradana North, Maradana South, and Dematagoda Wards.

Through the munificence of a benefactress, who preferred to remain anonymous, a fully qualified Maternity and General Nurse is now going through a special training in England and she will on her return assume duties as Matron of one of the two Centres.

During the year 183 babies were given free milk sufficient for 2 feeds per day, the total amount thus distributed being 2,090 gallons and $2\frac{1}{2}$ bottles at a cost of Rs. 5,017. From October, 1928, the milk allowed to the babies of St. Paul's, New Bazaar, San Sebastian, and Kotahena was given from the Child Welfare Centre where the mothers themselves are expected to come for it. This at least ensures that the milk given is unadulterated, clean, and diluted in the proper proportions to suit each individual baby, without leaving it in the hands of the poor ignorant mother who invariably forgets the instructions.

Statement 63 gives in figures the work done by the Health Visitors, and it is indeed a good record, the number of houses visited having increased from 99,025 in 1927 to 111,073 for 1928. With the supervision and instructional lectures delivered by the Medical Officer (Child Welfare) the Health Visitors are beginning to carry on their duties intelligently, tactfully, and with greater eagerness, showing a brighter outlook for the future.

The Municipal Midwives, whose services are given free to the poor, too have done very good work, having attended on 1,305 cases of labour. Statement 64 gives in detail the number of cases conducted by the Midwives for the year under review.

In a country like ours the co-operation of the public that may be expected in any new venture is given very tardily, no doubt due to the fact that the ideas of a great majority of the people are still very conservative, and Child Welfare work is no exception to this. Some have even expressed the opinion that the mere visiting of houses by the Health Visitors to inquire if the babies and mothers are doing well is only a wastage of time tending to no improved conditions of health. To them the glamour of a white coat, a few surgical instruments, and a large array of bottles with multi-coloured fluids are the only things that appeal. To such as these it is worth pointing out that what is more important in Child Welfare work, as in all fields of preventive medicine, is to see that the healthy ones are kept in good health so as to be less vulnerable to the host of disease-producing germs that are constantly on the lookout for a suitable host.

In conclusion, special mention may be made of the good and valuable work done by Dr. S. D. Fernando, the Acting Medical Officer in charge of Maternity and Child Welfare, from the day he took his duties up. His work has been marked by kindness; tact, and diligence, the qualities most essential to a Maternity and Child Welfare worker.



WAR MEMORIAL : CHILD WELFARE CENTRE, GINTUPITIYA.

REPORT OF THE ACTING MEDICAL OFFICER IN CHARGE OF MATERNITY AND CHILD WELFARE.

The Medical Officer of Health, Colombo.

I HAVE the honour to submit my report on the work done for the year ending December 31, 1928.

Dr. (Mrs.) M. C. Barclay having resigned her post at the end of October, I took up duties as Acting Medical Officer in charge of Maternity and Child Welfare on November 1, 1928. During August and September too I had acted in this capacity owing to the absence of Dr. Barclay on leave.

The Maternity and Child Welfare staff now consists of one Matron, 17 Health Visitors, and 12 Midwives, who are distributed as follows :—

| Ward. | | Number of Health Visitors. | | Midwives. | | Attached to |
|---------------|-----|----------------------------------|---|-----------|---|---|
| Kotahena | ... | 2 | } | ... | 7 | Child Welfare Centre with resident Matron. |
| St. Paul's | ... | 2 | | | | |
| New Bazaar | ... | 2 | | | | |
| San Sebastian | ... | 1 | | | | |
| Wellawatta | ... | 1 | | ... | 1 | Wellawatta Dispensary. |
| Kollupitiya | ... | 1 | | ... | 1 | Slave Island Dispensary. |
| Slave Island | ... | 2 | | ... | 1 | Slave Island Dispensary. |
| Maradana | ... | 3 | | ... | 1 | Maradana Dispensary. |
| Modera | ... | 2 | | ... | 1 | Modera Dispensary. |
| Relief | ... | 1 | | | | |

At the end of 1928 the number of patients, both pregrant mothers and children, who attended the clinics at the Centre and the Dispensaries, I am glad to report, has been noted to be gradually increasing.

In this connection I may mention that a good number of pregnant mothers that attend the clinics are Muslim women who were at one time thought not likely to take advantage of this maternity work.

The figures shown below will give an idea of the work done.

| | | Number of Pregnant Mothers attended to. | | Number of Children under One Year of Age attended upon. |
|--|-----|---|-----|---|
| Child Welfare Centre (from May to December) | ... | 565 | ... | 883 and 828 miscellaneous cases. |
| Wellawatta | ... | 65 | ... | 63 |
| Slave Island | ... | 131 | ... | 40 |
| Maradana | ... | 50 | ... | 82 |
| Modera | ... | 91 | ... | 93 |

} One Clinic per milk.

On 26 occasions Municipal Midwives have obtained the assistance of the Medical Officer in charge of Maternity and Child Welfare in difficult cases of labour conducted in the patients' homes, and 50 post-partum cases requiring medical attendance were also visited during the year.

Thirty-four times during the year the Municipal Midwives were inspected and instructed by lectures and otherwise. The same number of lectures and inspections were given to the Health Visitors too.

During the time that I was acting, I have had no occasion for the use of instruments in delivering cases. I found that all those cases requiring such treatment, I was able with tact, sympathy, and kindness to despatch to the Lying-in Home. In addition, in the interests of the patients, I was very diffident to deliver any such cases with instruments, particularly owing to the fact that the sanitary conditions of their homes were far from satisfactory for any operative interference, hampered further by even the want of a bed.

In conclusion, I wish to make special mention of the following officers who have done good work during the year :—

| | | | |
|----------------------|-----|-----|--------------------|
| 1. Miss Alice Ratnam | ... | ... | Matron. |
| 2. Mrs. M. S. Perera | ... | ... | Health Visitor. |
| 3. Mrs. A. Cruse | ... | ... | Health Visitor. |
| 4. Mrs. Erin Meier | ... | ... | Health Visitor. |
| 5. Miss E. Jansen | ... | ... | Health Visitor. |
| 6. Miss L. G. Wilson | ... | ... | Health Visitor. |
| 7. Inche Juhari | ... | ... | Municipal Midwife. |
| 8. N. Dharmaratna | ... | ... | Municipal Midwife. |
| 9. J. Arul Mary | ... | ... | Municipal Midwife. |

S. D. FERNANDO,

Colombo, January 31, 1929.

Acting Medical Officer, in Charge of Maternity and
Child Welfare.

(63) *Work done by Health Visitors during 1928.*

| Name. | No. of Houses visited. | Instructions <i>re</i> Infant Feeding. | No. of Tickets issued. | Municipal Midwife's Cases (visited . |
|---------------------------|---------------------------|---|---------------------------|--|
| Mrs. E. Raymond | ... 1,223 | ... 1,063 | ... 23 | ... 10 |
| Mrs. I. Zieseness | ... 5,859 | ... 2,276 | ... 22 | ... 51 |
| Mrs. A. Cruse | ... 9,701 | ... 6,214 | ... 11 | ... 81 |
| Mrs. I. Marsden | ... 3,434 | ... 3,194 | ... 29 | ... 53 |
| Miss L. G. Wilson | ... 7,431 | ... 5,380 | ... 77 | ... 99 |
| Mrs. E. Meier | ... 7,792 | ... 5,828 | ... 59 | ... 71 |
| Miss E. Jansen | ... 8,177 | ... 6,466 | ... 52 | ... 84 |
| Mrs. V. Misso | ... 7,531 | ... 5,828 | ... 36 | ... 62 |
| Miss A. Schokman | ... 8,062 | ... 5,459 | ... 33 | ... 117 |
| Mrs. M. M. Samarasekera.. | 6,130 | ... 4,146 | ... 3 | ... 124 |
| Mrs. M. S. Perera | ... 9,661 | ... 3,203 | ... 21 | ... 149 |
| Mrs. M. Fernando | ... 7,788 | ... 4,963 | ... 32 | ... 34 |
| Mrs. F. E. M. Harris | ... 7,423 | ... 4,386 | ... 128 | ... 96 |
| Mrs. M. John | ... 3,990 | ... 2,351 | ... 47 | ... 120 |
| Mrs. I. Ferdinand | ... 8,980 | ... 6,534 | ... 88 | ... 91 |
| Mrs. Martha Perera | ... 6,738 | ... 3,893 | ... 4 | ... 27 |
| Mrs. W. A. Thomasz | ... 1,153 | ... 612 | ... — | ... 39 |
| Total | ... 111,073 | 71,796 | 665 | 1,308 |

(64) *List of Cases conducted by Midwives, 1928.*

| Number. | Name of Midwife. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Total. |
|---------|------------------|----------|-----------|--------|--------|------|-------|-------|---------|------------|----------|-----------|-----------|--------|
| 1 | A. Fernando | ... 15 | 18 | 11 | 16 | 1 | 3 | 10 | 8 | 9 | 7 | 14 | 8 | 120 |
| 2 | P. M. Perera | ... 6 | 3 | 11 | 7 | 5 | 11 | 8 | 6 | 0 | 0 | 17 | 12 | 86 |
| 3 | E. Direckze ... | ... 9 | 10 | 8 | 6 | 2 | — | 3 | 8 | 9 | 23 | 13 | 7 | 98 |
| 4 | D. B. Dias ... | ... 18 | 12 | 12 | 11 | 9 | 16 | 9 | 12 | 6 | 22 | 19 | 15 | 161 |
| 5 | R. Perera ... | ... 8 | 2 | 8 | 8 | 1 | 7 | 5 | 5 | 6 | 9 | 3 | 9 | 71 |
| 6 | N. Dharmaratne | ... 27 | 13 | 14 | 10 | 4 | 6 | 10 | 9 | 14 | 13 | — | — | 120 |
| 7 | M. Sathasivam | ... 8 | 7 | 6 | 10 | 5 | 3 | 7 | 4 | 15 | 5 | 5 | 16 | 91 |
| 8 | D. M. Pallawela | ... 15 | 8 | 9 | 10 | 15 | 11 | 9 | 12 | 16 | 16 | 17 | 8 | 146 |
| 9 | M. P. Jayasinghe | ... 11 | 3 | 8 | 5 | 6 | 7 | 11 | 6 | 10 | 5 | 9 | 2 | 83 |
| 10 | Inche Juhari | ... 7 | 11 | 22 | 11 | 10 | 15 | 14 | 25 | 19 | 27 | 20 | 24 | 205 |
| 11 | J. Arul Mary | ... — | — | — | — | 1 | 9 | 4 | — | 9 | 9 | 5 | 17 | 54 |
| 12 | P. Dassanayake | ... 7 | 3 | — | 1 | — | — | — | — | — | — | — | — | 11 |
| | Alice Nona | ... — | — | — | — | 4 | 7 | 6 | 6 | 7 | — | — | — | 30 |
| | K. C. Perera | ... — | — | — | — | — | — | — | — | — | 16 | 7 | 6 | 29 |
| | Total | ... 131 | 90 | 109 | 95 | 63 | 95 | 96 | 101 | 120 | 152 | 129 | 124 | 1,305 |

(65) *Statement of Expenditure on Milk supplied to Infants by the Child Welfare Branch during the Year 1928.*

| Month. | No. of Bottles of Milk. | Cost of Milk. Rs. c. | Month. | No. of Bottles of Milk. | Cost of Milk. Rs. c. |
|----------|----------------------------|-------------------------|-----------|----------------------------|-------------------------|
| January | ... 965 | ... 386 0 | September | ... 1,091 | ... 436 40 |
| February | ... 928½ | ... 371 40 | October | ... 1,087 | ... 434 80 |
| March | ... 1,084½ | ... 433 80 | November | ... 1,102½ | ... 441 0 |
| April | ... 1,070½ | ... 428 20 | December | ... 1,249 | ... 499 60 |
| May | ... 1,042½ | ... 417 0 | | | |
| June | ... 944½ | ... 377 80 | | 12,542½ | 5,017 0 |
| July | ... 1,020½ | ... 408 20 | | | |
| August | ... 957 | ... 382 80 | | | |

Total amount of milk supplied during 1928, 2,090 gallons and 2½ bottles.

Total cost of milk supplied during 1928, Rs. 5,017.

Number of children who participated in free milk, 183.

(66) *Ante-natal Clinics done by the Medical Officer (Child Welfare) during 1928.*

| Dispensaries. | | | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Total. |
|----------------------|-----------|-----|----------|-----------|--------|--------|------|-------|-------|---------|------------|----------|-----------|-----------|--------|
| Child Welfare Centre | { Mothers | ... | — | — | — | — | 33 | 25 | 30 | 48 | 107 | 73 | 131 | 126 | 573 |
| | { Babies | ... | — | — | — | — | 15 | 49 | 52 | 73 | 75 | 103 | 200 | 227 | 794 |
| Wellawatta | { Mothers | ... | 4 | Nil | 2 | 5 | 3 | Nil | Nil | 9 | 13 | 5 | 15 | 12 | 68 |
| | { Babies | ... | 14 | 3 | 4 | 3 | Nil | Nil | Nil | 2 | 9 | 2 | 6 | 14 | 57 |
| Maradana | { Mothers | ... | 1 | 12 | 6 | 5 | 6 | Nil | 3 | 4 | 10 | — | — | — | 37 |
| | { Babies | ... | 14 | 12 | 9 | 7 | 2 | Nil | 2 | 17 | 19 | — | — | — | 82 |
| Slave Island | { Mothers | ... | 8 | 6 | 15 | 11 | 8 | 5 | 5 | 15 | 25 | 8 | 8 | 14 | 128 |
| | { Babies | ... | Nil | Nil | 4 | 4 | 3 | Nil | 1 | 2 | 1 | 4 | 4 | 2 | 25 |
| Mutwal | { Mothers | ... | 10 | 6 | 1 | 6 | 1 | Nil | 8 | 6 | 11 | 3 | 20 | 20 | 92 |
| | { Babies | ... | 10 | 2 | 8 | 10 | Nil | Nil | 1 | 18 | 18 | 4 | 6 | Nil | 77 |
| St. Paul's | { Mothers | ... | 3 | 2 | 6 | — | — | — | — | — | — | — | — | — | 11 |
| | { Babies | ... | 10 | 6 | 30 | 3 | — | — | — | — | — | — | — | — | 49 |
| New Bazaar | { Mothers | ... | 5 | 2 | 2 | 2 | — | — | — | — | — | — | — | — | 11 |
| | { Babies | ... | 4 | 4 | — | — | — | — | — | — | — | — | — | — | 8 |

Non-Municipal Child Welfare Work.

De Soysa Lying-in Home Ante-natal Clinic.—The Superintendent gives the following figures of the work done:—

| | | 1927. | | 1928. |
|---------|-----|-------|-----|-------|
| Persons | ... | 1,589 | ... | 1,702 |
| Visits | ... | 1,731 | ... | 1,960 |

The Child Welfare Association's Crèche.—The Honorary Secretary reports as follows:—

“At present the number of children on the register is 60 with an average daily attendance of 35 children between 7 days to 7 years are admitted. When children are old enough to go to school they are sent to the Government school near by. Such children are given a free meal and looked after till their mothers are able to take them home after work. The Crèche was opened as a model hoping that other organizations may open similar ones in other parts of the City. It is hoped that women interested in all women's movements and the uplifting of their poorer sisters will come forward and help and encourage those who try to help themselves without resorting to begging.”

Ceylon Social Service League (Women's Branch).—The Honorary Secretary has been good enough to furnish me with the following facts:—

1. *The Clinic at Headquarters, Maradana.*—This is open twice a week at 8'30 A.M., on Thursdays and Sundays, the doctors in charge being Dr. T. H. Goonewardana and Dr. C. J. C. de Silva, whose services are given free.

The drugs are supplied by the Director of Medical and Sanitary Services, the dispensing being done by Mr. C. X. Pinto.

Maradana Milk Dépôt.—Twelve bottles of milk are distributed daily to 36 babies. Nursing and expectant mothers are also supplied with barley, rice, condensed milk, and other such foods twice a week, and in special cases daily help is given.

2. *Slave Island Milk Dépôt.*—An average of 12 bottles is distributed daily to 24 babies.
3. *Kotahena Milk Dépôt.*—Eight to nine bottles of milk are distributed daily to 20 babies.
4. *Bambalapitiya Milk Dépôt.*—Temporarily closed during the year owing to lack of accommodation and workers, but has been reopened in January, 1929.
5. *Cotta Road Milk Dépôt.*—This is being run by Mrs. F. R. Senanayake and 8 bottles of milk are distributed daily to 20 babies.

XXXVII.—STAFF CHANGES.

Medical Officer of Health.—Dr. C. V. Aserappa, Medical Officer of Health, went on long leave for 8 months and 13 days on August 27, 1928, when Dr. C. H. Gunasekera, Chief Assistant Medical Officer of Health, assumed duties as Acting Medical Officer of Health.

Assistant Medical Officer of Health (Child Welfare).—Dr. (Mrs.) M. C. Barclay, Assistant Medical Officer of Health (Child Welfare), resigned on October 3, 1928, and Dr. S. D. Fernando, Medical Officer, Modera Dispensary, was appointed to act as Medical Officer (Maternity and Child Welfare) as from November 1, 1928. The post of Medical Officer, Modera Dispensary, was temporarily filled by the following doctors:—

Dr. E. J. Ratnayake from November 1 to 4, 1928, Dr. R. G. Perera from November 5 to December 18, 1928, and Dr. C. V. Gunawardene thereafter.

Medical Officer, San Sebastian Female Dispensary.—Pending the appointment of a Female Medical Officer, this post was temporarily filled by the following male doctors :—

Dr. E. J. Ratnayake from August 17 to September 27, 1928, Dr. R. G. Perera from September 28 to November 4, 1928, and Dr. E. J. Ratnayake from November 5, 1929, onwards.

Clerical Staff.—Mr. P. Cornelis appointed Clerk, Division II., on February 22, 1928, to succeed Mr. E. B. Fernando, appointed Sub-Inspector.

Mr. T. H. F. Ruberu appointed Clerk, Division II., on April 18, 1928. (New post.)

Mr. J. E. Speid appointed Clerk, Division II., on August 2, 1928, to succeed Mr. T. H. F. Ruberu, transferred to the Municipal Treasurer's Department.

Mr. L. P. Silva, Division II. Clerk, Assessor's Department, was promoted to Division I. as Laboratory Clerk on November 1, 1928. (New post.)

Inspectors.—Mr. W. St. G. Blacker, Sanitary Inspector, appointed Food Inspector in February, 1928. (New post.)

Mr. C. P. de Zoysa, Sub-Inspector, was promoted on February 1, 1928, to the post of Sanitary Inspector, vacated by Mr. W. St. G. Blacker.

Sub-Inspector.—Mr. B. Fernando, Clerk, Division II., was appointed Sub-Inspector as from February 22, 1928, to fill vacancy caused by the promotion of Mr. C. P. de Zoysa.

Apothecaries.—Mr. P. A. Schokinan appointed Clerk Apothecary, Slave Island Dispensary, on October 8, 1928, to succeed Mr. G. P. Jayawardene, resigned.

Matron Child Welfare Centre.—Miss Alice Ratnam, who was appointed to the post of Health Visitor on March 1, 1928, and was later appointed Female Dispenser of San Sebastian Dispensary on September 1, 1928, was appointed Matron of the Child Welfare Centre on December 1, 1928.

Health Visitors.—Mrs. Martha Perera, appointed Health Visitor on February 15, 1928, to succeed Mrs. C. E. Alphonso, retired.

Mrs. Ida Ferdinands, appointed Health Visitor on February 15, 1928. (New post.)

Mrs. W. A. Thomas, appointed Health Visitor on May 16, 1928. (New post.)

Cemetery-keepers.—Mr. V. Jansz, appointed Assistant Cemetery-keeper, Kanatte Cemetery, on July 1, 1928, to succeed Mr. B. de Livera, transferred as Cemetery-keeper, Liveramentu Cemetery.

Market-keeper.—Mr. D. C. Wijesinghe, appointed Grade II. Market-keeper on June 1, 1928. (New post.)

Mr. L. R. Andriesz, appointed Grade II. Market-keeper on June 13, 1928. (New post.)

Mr. H. M. Caldera, appointed Grade II. Market-keeper on September 19, 1928, to succeed Mr. B. A. Perera, retired.

Mr. F. D. Alagoda, appointed Grade II. Market-keeper on December 20, 1928, to succeed Mr. P. D. Martin, appointed Clerk in the Municipal Engineer's Department.

Midwives.—Mrs. J. Arul Mary, appointed Midwife on May 16, 1928. (New post.) Mrs. Alice Nona, appointed Midwife on May 16, 1928, to succeed Mrs. P. Dassanayaka, dismissed.

Mrs. K. Cecilia Perera, appointed Midwife on November 1, 1928, to succeed Mrs. Alice Nona, dismissed.

Bicycle Orderly.—S. Marthelis Perera, appointed Bicycle Orderly at Child Welfare Centre on May 14, 1928. (New post.)

M. Donies de Costa, appointed Bicycle Orderly at Child Welfare Centre on June 7, 1928. (New post.)

S. K. Seyid Hashim Bhai, appointed Dispensary Orderly, San Sebastian Dispensary, June 20, 1928.

T. S. J. Ismail, appointed Hall Porter at Child Welfare Centre on August 8, 1928. (New post.)

XXXVIII.—BACTERIOLOGICAL LABORATORY.

The report of the City Microbiologist, Dr. Hirst, gives an account of the work done at the Municipal Laboratory during the year under review. (*Vide* Annexure A.)

I would specially commend to the reader that part of Dr. Hirst's report dealing with the water supply of the City. It is most interesting and instructive. Although a great part of it is purely technical and would be of much use and advantage to the scientific minds, others too may gain a great deal of information by its close perusal.

His investigations show clearly the dangers that the City's water supply is exposed to, and it would be well to put in hand the suggestions he has advocated therein without much delay, for a pure and potable water supply is undoubtedly the prime necessity to good health.

XXXIX.—ANALYTICAL WORK.

A report of the work undertaken by the City Analyst on behalf of the Council is given here as Annexure B.

Town Hall,
Colombo, April 17, 1928.

C. H. GUNASEKARA,
Acting Medical Officer of Health.

Annexure A.

REPORT OF THE CITY MICROBIOLOGIST FOR 1928.

The reconditioning and equipment of the extended laboratory made considerable progress during the year. The Council have voted the necessary funds for the completion of the work in 1929. The improvements already effected will enable a much more varied programme of microbiological research to be undertaken in the future. Steady progress may be anticipated on the purely epidemiological side.

As regards communicable diseases survey work, attention is directed to the introductory paragraphs of the annual report for 1926. No outdoor staff is attached to the laboratory such as is available for field research in the epidemiology of malaria and hookworm disease under Government. The nearest approach to it is the rat destruction corps under the Municipal Veterinary Surgeon, which has rendered such signal service in the collection of material for research on the parasitology of plague. At present progress in this direction depends on the initiative of the officers of the Public Health Department and the medical profession practising in Colombo.

It is gratifying to be able to report that several senior members of the staff of the General Hospital are offering valuable clinical material from cases in their wards. It is hoped, with their assistance, to make a start this year with the classification of pneumonic types as they occur among Colombo residents in hospital, and to pursue the investigation into the cause of continued fever in Colombo.

(a) Distribution of Clinical Specimens.

| | | | Examined for | Number Received. | Number Positive. |
|--------------------------------------|-----|-----|--------------|---------------------|---------------------|
| Diagnostic service for practitioners | ... | { | Enteric | 163 | 26 |
| | | | Tuberculosis | 91 | 20 |
| | | | Dysentery | 114 | 20 |
| | | | Diphtheria | 41 | 10 |
| | | | Hookworm | 94 | 49 |
| | | | Malaria | 14 | — |
| | | | Various | 179 | 111 |
| Public Health Department | ... | { | Enteric | 652 | 15 |
| | | | Human plague | 13 | 7 |
| | | | Tuberculosis | 13 | 3 |
| | | | Dysentery | 9 | 1 |
| | | | Diphtheria | 19 | — |
| | | | Hookworm | 17 | 11 |
| | | | Malaria | 1 | — |
| | | | Leprosy | 2 | 1 |
| Veterinary Department | ... | ... | Various | 31 | 12 |
| | | | Anthrax | 4 | 2 |
| | | | | 1,457 | 288 |

Of the 815 enteric specimens, 716 comprise finger blood for Widal's reaction, 25 blood cultures, 39 fæces, and 35 urines.

(b) General Distribution of Specimens examined during 1928.

| | | | |
|------------------------------------|-----|-----|--------|
| Clinical specimens | ... | ... | 1,471 |
| Town water | ... | ... | 172 |
| Rat fleas for species distribution | ... | ... | 12,882 |
| Rodents for plague :— | | | |
| Port Commission | ... | ... | 5,358 |
| Veterinary Department | ... | ... | 15,405 |
| Public Health Department | ... | ... | 1,884 |
| Rodents for flea index :— | | | |
| Port Commission | ... | ... | 182 |
| Veterinary Department | ... | ... | 5,072 |
| Miscellaneous | ... | ... | 52 |
| | | | 42,478 |

Including 13 Bandicoots examined for plague, the total is 42,491.

(c) Distribution of Rodents examined for Plague in 1928.

(1) By Mode of Capture.

| Species. | | | Number examined. | Number infected. | | Percentage infected. | | |
|------------------------------|---|---------------|---------------------|---------------------|-----|-------------------------|-----|-------|
| Trapped rats | { | R. rattus | ... | 15,973 | ... | 4 | ... | 0·03 |
| | | R. norvegicus | ... | 3,486 | ... | 5 | ... | 0·14 |
| | | M. musculus | ... | 749 | ... | 0 | ... | — |
| | | Bandicoots | ... | 3 | ... | 0 | ... | — |
| Rats found dead... | { | R. rattus | ... | 29 | ... | 3 | ... | 10·34 |
| | | R. norvegicus | ... | 56 | ... | 6 | ... | 10·71 |
| | | M. musculus | ... | 3 | ... | 0 | ... | — |
| Rats killed by fumigation | { | R. rattus | ... | 424 | ... | 0 | ... | — |
| | | R. norvegicus | ... | 1,397 | ... | 1 | ... | 0·07 |
| | | M. musculus | ... | 530 | ... | 0 | ... | — |
| | | Bandicoots | ... | 10 | ... | 0 | ... | — |
| | | | | <hr/> | | <hr/> | | |
| | | | | 22,660 | | 19 | | 0·08 |

(2) By Species and Source.

| | | Trapped Alive. | | | Found Dead. | | | Killed by Fumigation. | | |
|---------------|-----|--|------------------|-----------------------|-------------------------|------------------|-----------------------|-----------------------|------------------|-----------------------|
| | | Number examined. | Number infected. | Percentage infection. | Number examined. | Number infected. | Percentage infection. | Number examined. | Number infected. | Percentage infection. |
| R. rattus | ... | { Veterinary Department 14,767 ... 1 ...0'007... | | | { 10 ... — ... — | | | { | | |
| | ... | { Public Health Department | | | { 19 ... 3 ...15'79 ... | | | { 297 ... — ... — | | |
| | ... | { Port Commission ... 1,206 ... 3 ...0'25 ... | | | { — ... — ... — | | | { 127 ... — ... — | | |
| R. norvegicus | ... | { Veterinary Department 270 ... 2 ...0'74 ... | | | { 13 ... — ... — | | | { | | |
| | ... | { Public Health Department | | | { 43 ... 6 ...13'95 ... | | | { 1,057 ... 1 ...0'09 | | |
| | ... | { Port Commission ... 3,216 ... 3 ...0'09 ... | | | { — ... — ... — | | | { 340 ... — ... — | | |
| M. dubius | ... | { Veterinary Department 345 ... — ... — | | | { — ... — ... — | | | { | | |
| | ... | { Public Health Department | | | { 3 ... — ... — | | | { 465 ... — ... — | | |
| | ... | { Port Commission ... 404 ... — ... — | | | { — ... — ... — | | | { 65 ... — ... — | | |

Three trapped Bandicoots, *Bandicota malabarica*, and ten killed by fumigation were negative for plague.

(d) Monthly Flea Index.

| Number of Rats examined. | | | | Flea Index. | Number of Rats examined. | | | | Flea Index. |
|-----------------------------|-----|-----|-----|-------------|-----------------------------|-----|-----|-----|-------------|
| Month. | | | | | Month. | | | | |
| January | ... | 43 | ... | 3'44 | July | ... | 756 | ... | 1'59 |
| February | ... | 238 | ... | 2'7 | August | ... | 597 | ... | 2'07 |
| March | ... | 176 | ... | 2'19 | September | ... | 609 | ... | 2'13 |
| April | .. | 193 | ... | 2'28 | October | ... | 700 | ... | 2'64 |
| May | ... | 253 | ... | 1'56 | November | ... | 657 | ... | 3'35 |
| June | ... | 575 | ... | 2'58 | December | ... | 457 | ... | 3'6 |

(e) Seasonal Prevalence of Rat Fleas in Endemic Plague Area, 1928.

| Month. | | Rats. | | Fleas. | | Flea Index. | | Cheopis. | | Astia. | | P. r Cent. Cheopis. | | Cheopis Index. |
|-----------|-----|-------|-----|--------|-----|-------------|-----|----------|-----|--------|-----|---------------------|-----|----------------|
| January | ... | 24 | ... | 111 | ... | 4'3 | ... | 33 | ... | 78 | ... | 29'7 | ... | 1'4 |
| February | ... | 148 | ... | 459 | ... | 3'1 | ... | 115 | ... | 344 | ... | 25'1 | ... | 0'8 |
| March | ... | 108 | ... | 283 | ... | 2'6 | ... | 107 | ... | 176 | ... | 37'8 | ... | 1'0 |
| April | ... | 112 | ... | 294 | ... | 2'6 | ... | 90 | ... | 204 | ... | 33'7 | ... | 0'8 |
| May | ... | 98 | ... | 243 | ... | 2'5 | ... | 106 | ... | 137 | ... | 43'6 | ... | 1'1 |
| June | ... | 83 | ... | 294 | ... | 3'5 | ... | 73 | ... | 221 | ... | 24'8 | ... | 0'9 |
| July | ... | 76 | ... | 192 | ... | 2'5 | ... | 52 | ... | 140 | ... | 27'1 | ... | 0'7 |
| August | ... | 188 | ... | 376 | ... | 2'0 | ... | 77 | ... | 299 | ... | 20'5 | ... | 0'4 |
| September | ... | 154 | ... | 400 | ... | 2'6 | ... | 112 | ... | 288 | ... | 28'0 | ... | 0'7 |
| October | ... | 178 | ... | 598 | ... | 3'3 | ... | 98 | ... | 500 | ... | 16'4 | ... | 0'6 |
| November | ... | 121 | ... | 525 | ... | 4'3 | ... | 98 | ... | 427 | ... | 18'7 | ... | 0'8 |
| December | ... | 112 | ... | 622 | ... | 5'6 | ... | 114 | ... | 508 | ... | 18'3 | ... | 1'0 |
| | | 1,402 | | 4,397 | | 3'1 | | 1,075 | | 3,322 | | 24'4 | | 0'8 |

BACTERIOLOGICAL EXAMINATION OF SAMPLES OF ICE CREAM.

Seventeen samples of ice cream were examined during the year for evidence of faecal pollution or excessive bacterial content. Five samples showed an agar colony count in excess of one million organisms per cubic centimeter after 48 hours at 37° C.; the highest count being 4,874,000, the lowest count 30,000 per c.c. Five samples showed acid and gas in lactose bile salt broth (presumptive coli test) in a dilution of 1/10,000 and over of the melted cream. Streptococci were visible microscopically in the centrifuged deposit from 10 c.c. of one cream and another showed obvious dirt in this deposit. On working out the characters of the lactose fermenters isolated from the 10 c.c. of melted cream after 18 hours incubation at 37° C. in lactose bile broth it was found that true faecal *B. coli* were relatively scarce. 110 colonies were tested in lactose, saccharose, dulcitate and adonite broths and by the carbinol and indol tests, but none of them were typical faecal organisms. *B. coli communis*, *B. neapolitanus*, No. 71, *B. acidi lactici*, and members of the *B. vesiculosus* group were conspicuous by their absence.

It is difficult to lay down arbitrary standards for samples of this description. According to Buchan there should not be more than one million organisms capable of growing on agar at blood heat in two days.

It may be pointed out that *B. typhosus* has been proved to have a much greater longevity at low than at tropical temperatures, and that infected ice cream would be a medium for its preservation in the infective state. Though every precaution should be taken to insure cleanliness in preparation, that being the factor which probably governs the bacterial count, it is probable that the health of the vendor or manufacturer is the primary consideration. A dysentery or enteric carrier engaged in the ice cream trade might prove a potent agent in disseminating disease among consumers of this delicacy.

It will be remembered that an epidemic of food poisoning occurred among the guests at the Post Office Sports Club fete on November 8, 1924. Ice cream was the only article of food ingested by all the sufferers in this outbreak. The writer showed that the infecting organism was *B. aertrycke*. Absorption and agglutination tests proved its identity with the well-known "Mutton" strain.

FOOD POISONING.

An investigation was undertaken in conjunction with Dr. F. N. Jayawardene, Second Assistant to the Medical Officer of Health, into the cause of the fatal outbreak of food poisoning among the customers of a certain eating house in Fifth Cross street, Pettah.

No bacilli of the Salmonella group could be isolated from the fresh faeces of five of the victims, though these faeces all showed marked evidence of irritation of the intestinal mucous membrane in the form of cellular exudate and mucus. Numerous plates of lactose bile agar were inoculated with entirely negative results. The blood serum of one of these cases, however, had a slight, but distinct, agglutinative action on two strains of *B. aertrycke*, one of the local strain isolated by the writer from the faeces of a victim of the ice cream of food poisoning outbreak in Colombo in 1924, the other a strain of *B. aertrycke* (Mutton) from the Lister Institute. There was also a trace of agglutination when tested against *B. enteriditis* (Gærtner). The blood of the employees in the kitchen of the eating-house was tested against these two strains of *B. aertrycke*, *B. enteriditis* (Gærtner) and the Newport (Salmonella) emulsion issued by the Oxford Standards Laboratory with negative results.

A series of samples of tinned fish were also examined. A number of them had undergone putrefaction and were unfit for human consumption, but no organisms of the food poisoning group were isolated and the fish was consumed by laboratory animals without ill effects. Contrary to popular belief, putrid food does not commonly give rise to serious outbreaks of food poisoning; in the vast majority of such outbreaks the food affected is not noticeably altered in either appearance, taste, or smell.

It often happens that the living organism responsible for a food poisoning outbreak cannot be isolated. It is killed in the cooking or canning of the food as soon as a temperature of 60° C. is reached. The symptoms are due to the irritant action on the mucous membrane of the stomach and intestine of toxic products generated in the food during the growth of the organism. These toxins can resist a temperature well over the boiling point of water. The longer the period of growth of the organism before the food was cooked the greater the amount of toxin generated by it.

The agglutinins found in the blood of one of the cases may represent a real response to the consumption of a heat stable agglutininogen or it may be that the serum of that particular patient exerted a spontaneous agglutinative effect on *B. aertrycke* in the low dilutions employed.

The most probable explanation of the outbreak seems to be that some food became heavily infected with a bacillus of the Salmonella group and that it was subsequently cooked and served either in whole, or, more probably, in successive portions, to those patrons of the eating-house who subsequently fell ill.

RAT-FLEA SURVEYS.

(1) Kandy.

During the first quarter of the year the writer was engaged by the Municipality of Kandy to investigate and report on the factors governing the spread of the second plague outbreak in that town which began at the end of November, 1927, and terminated at the end of February, 1928, giving rise in the interim to 38 human and 43 rat cases. Special attention was paid to the flea species factor and a rat-flea survey was organized of the Kandy District. The rats and fleas were collected by the anti-plague staff under the direction of Dr. Merl Perera in accordance with a plan of operations laid down by the writer. The officer from the Bacteriological Institute, who conducted the rat examinations for plague, was trained in the identification of rat-fleas. The results were checked by the writer, whose detailed report will be printed as a Sessional Paper.

The rat is the same species, *R. rattus kandiannus*, as is most prevalent in domestic premises in Colombo, but the large gray outdoor rat *R. norvegicus* is entirely absent. On the other hand the mole rat, *Gunomys gracilis*, proved to be more common in Kandy than in Colombo, particularly in the neighbourhood of Trincomalee street.

So far as domestic premises are concerned the catch of rats and fleas may be considered fairly representative of the rat-flea population of the district surveyed, but the figures available in respect of commercial premises (boutiques, grain shops, eating-houses, &c.) were too small for biometric purposes owing to the relatively small number of rats trapped. In all probability the rat colonies in the bazaar quarter of the town had been devastated by the plague epizootic.

Forty-seven rats trapped in residential premises in Kandy town plague area yielded 197 fleas of which 168 or 85·3 per cent. were *X. cheopis*, the *cheopis* flea index being 3·57. Residential plague-free area premises in Kandy town yielded 728 fleas, 498 of these were *X. cheopis*, 68·3 per cent., and 230 *X. astia*, 31·7 per cent., the *cheopis* index was 2·45.

Residences in the Peradeniya suburb, south of the town, yielded 117 *X. cheopis*, 100 *X. astia*, 217 fleas in all, *X. cheopis* 53·9 per cent. and the *cheopis* index 1·43. The northern suburb of Katugastota yielded 54 rats, 155 fleas, 110 *X. cheopis*, 71 per cent. of the total, *cheopis* index 2·04. Gampola, the nearest town towards the south of the Kandyan plateau, yielded 30 *X. cheopis* out of 52 fleas, or 57·9 per cent. In all districts *X. cheopis* infestation of commercial premises was higher than for the neighbouring domestic ones. When the distribution of the catch is spotted on a map it is seen that the pure takes of *X. astia*, i.e., rats bearing *X. astia* only and no *X. cheopis*, all occurred at the periphery of the district surveyed.

X. cheopis was also found to be the predominant rat-flea during the 1920 outbreak of plague in Kandy.

On analysing the meteorological data for Kandy supplied by the Government Meteorologist, it is seen that the mean monthly temperature falls within the range favourable to *X. cheopis* propagation (68°F.–78°F.) all the year round and that the saturation deficiency only falls below the critical limit, 0·3 inch, during the months of February and March. In other words, Kandy, situated as it is at an elevation of 1,600–1,700 feet, enjoys a much cooler climate than Colombo, but one much more favourable to both *X. cheopis*, the principal plague flea, and to the survival of plague-infected rat-fleas of all species.

Taking the district as a whole there were 1,018 or 69·6 per cent *X. cheopis* among 1,463 fleas, *cheopis* index 2·38. This figure may be contrasted with the *R. rattus-cheopis* index, 1·44 for the transport warehouses in Colombo during the survey of 1922–24 and with 0·83 the corresponding index for the Pettah district, the most heavily plague-infected part of Colombo. According to the writer's epidemiological ideas these figures indicate that plague epizootics in Kandy will tend to be more severe but less persistent than in Colombo when the difference in climate is taken into account.

Recent work in Ceylon and India indicates increasingly clearly that *X. astia* is a flea adopted to a much more restricted range of climatic conditions than *X. cheopis*. It would appear to have originated in and to be specially adopted to the humid and warm territories in the vicinity of the Bay of Bengal. We do not know what rodents and fleas were found in the highlands of Ceylon before jungle clearing for the coffee plantations began. In all probability neither the rat *R. rattus kandiannus* nor the flea *X. cheopis* are indigenous to these territories, but have been imported and established themselves under conditions favourable to their propagation. No rat-flea survey of the Central Province above 2,000 feet has yet being undertaken, but the writer ventures to predict that *X. astia* will be found to be comparatively scarce at elevations over 4,000 feet.

These findings have a bearing on the question of fumigation of imported rice. It would appear that *X. cheopis* is already established on the domestic rats of the principal townships of the Central Province. Hence there is no point in fumigating rice destined for these stations with the sole object of disinfecting it from the eggs and larvæ of *X. cheopis*. In the case of Colombo certainly, and the low-country districts probably, effective fumigation achieves a two-fold object. It not only safeguards against the transference of infection from place to place, but it also eliminates the chief carrier insect and prevents its spread into new territory. It should be borne in mind, however, that large quantities of grain other than rice pass through the boutiques in the *cheopis* infested Pettah district, not only to all parts of Colombo, but to Kandy and many low-country stations.

The writer found that the citizens of Kandy were much concerned about the rat-proofing of the Kandy inwards railway goods shed. It may be pointed out that the condition of the outwards goods shed at Maradana is, epidemiologically, much more important, since it lies between the two districts in Colombo most liable to plague infection. Nine plague-infected rats have actually been found in the Maradana goods yard. The present outward goods shed affords every facility for the transference of plague rats from Colombo to Kandy by rail. No grain is now stored there overnight, but the shed requires to be rebuilt on rat-free lines on a rat-proof platform.

(2) *Kalutara.*

The results obtained from the recent rat-flea survey carried out by the Kalutara Health Unit are very significant. The fleas were identified by the writer on behalf of the Unit, and as in the case of Kandy a distinction was drawn between domestic and commercial premises. Not a single *X. cheopis* was found among the 1,508 rat-fleas so far examined, all were *X. astia* save one, a *Ctenocephalus felis*. The flea index for the 140 *R. rattus kandiannus* trapped in commercial premises was 3·4 and that given by the 397 rats trapped in residential premises 2·6.

It is doubtful, however, whether the commercial collection included sufficient fleas from the boutiques where imported grain is stored. The results strengthen the evidence that *X. astia* is the indigenous rat flea of low-country Ceylon.

(3) *Colombo.*

It will be remembered that the 1922-24 rat-flea survey showed no *cheopis* infested premises in the district of Kotahena Central, and only two in Wellawatta South with a *cheopis* percentage of only 0·6. Concordant results were obtained for the two plague seasons 1922-23 and 1923-24.

During 1926 further observations were carried out in the Mutwal and Kotahena districts. The results are shown in the annual report for that year and are reproduced below :—

Mutwal and Kotahena, 1926.

| Month. | Rats. | | Fleas. | | Astia. | | Cheopis. | | Per Cent. Cheopis. | | Flea Index. | | Cheopis Index. | |
|----------|-------|-----|--------|-----|--------|-----|----------|---|-----------------------|------|----------------|------|-------------------|-------|
| January | ... | 209 | ... | 236 | ... | 233 | ... | 3 | ... | 1·27 | ... | 1·13 | ... | 0·01 |
| February | ... | 239 | ... | 281 | ... | 277 | ... | 4 | ... | 1·42 | ... | 1·18 | ... | 0·02 |
| March | ... | 210 | ... | 396 | ... | 389 | ... | 5 | ... | 1·76 | ... | 1·89 | ... | 0·03 |
| April | ... | 375 | ... | 666 | ... | 661 | ... | 7 | ... | 0·75 | ... | 1·78 | ... | 0·02 |
| May | ... | 424 | ... | 968 | ... | 966 | ... | 2 | ... | 0·20 | ... | 2·29 | ... | 0·005 |

The above figures apply to fleas caught on *Rattus rattus kandinus*.

During the second quarter of 1928 the Wellawatta and Kotahena districts were surveyed more intensively. The results obtained during May showed a disquietingly high incidence of *X. cheopis* on the 116 rats searched from these non-plague districts, no less than 10·4 per cent. A number of *cheopis* infested rats were caught during the second quarter of the year both in Wellawatta South and in the formerly *cheopis* free district of Kotahena Central.

On reference to Table (e) it will be noted that *X. cheopis* incidence in the endemic plague area (Pettah, Sea street and adjoining streets) also reached a remarkably high figure during May, the highest in fact so far recorded, 43·6 per cent., *cheopis* index 1·08. In view of this it was decided to resurvey the whole city as soon as possible.

The method adopted differed materially from that used for the 1922-24 flea survey, the results of which are recorded in full detail in Part II. of the writer's memoir of Researches on the Parasitology of Plague; that survey was restricted to the period November, December, January, and February, *i.e.*, the season when plague is most prevalent in Colombo, in order that the percentage figures of species flea prevalence might be correlated with the corresponding incidence of plague as accurately as possible.

At present, however, plague is not prevalent to any extent in Colombo, and it is now apparent that the variations in *cheopis* prevalence are not governed primarily by the comparatively slight seasonal variations in climate at this station. Amount of *cheopis* infested grain has, probably, a much greater influence.

The writer was lead by the results of the preliminary 1921 flea survey to believe that abnormal hot weather would favour *X. astia* and tend to eliminate *X. cheopis*. The hot weather collection of that year, however, which showed only a few *X. cheopis*, was not really representative of the endemic plague zone flea population and the importance of the grain factor was not then fully realized. There is no definite *X. cheopis* season. Thus during May, 1926 (hot weather), the *X. cheopis* percentage in the endemic plague zone was only 7·96, *cheopis* index 0·20, the lowest figure for that year, whereas in May, 1928, *X. cheopis* percentage in the same area reached a record figure for any time of year. As far as Colombo is concerned, climate exerts its influence on the plague transmitting power of the individual *X. cheopis*, which is markedly increased when temperature falls below 80°F.

In view of the above it was thought legitimate to carry on the survey right through the year. During the first six months each rat was separately searched by hand, but later, when the observations were extended, the *R. rattus* flea catch from each premises was averaged, the cloth covered cages being introduced into a box and exposed to hydrogen cyanide gas generated from calcium cyanide A dust. Distinctly higher flea indices are obtained by this latter method which is the one recommended for general use. It has the disadvantage that the ratio of flea bearing to non-flea-bearing rats is not available.

The gross percentage results obtained by these surveys are set forth below :—

| | | | Total Fleas. | Per Cent. <i>X. cheopis</i> . | | Per Cent. <i>X. astia</i> . | |
|------------------------|-----|-----|--------------|----------------------------------|------|--------------------------------|------|
| Pettah | ... | ... | 3,023 | ... | 26·7 | ... | 73·3 |
| St. Paul's | ... | ... | 2,007 | ... | 20·4 | ... | 79·6 |
| San Sebastian | ... | ... | 564 | ... | 3·7 | ... | 96·3 |
| Slave Island | ... | ... | 1,154 | ... | 2·2 | ... | 97·8 |
| New Bazaar | ... | ... | 641 | ... | 2·8 | ... | 97·2 |
| Maradana | ... | ... | 928 | ... | 1·2 | ... | 98·8 |
| Kotahena | ... | ... | 1,444 | ... | 2·8 | ... | 97·2 |
| Kollupitiya... | ... | ... | 2,577 | ... | 1·4 | ... | 98·6 |
| Fort | ... | ... | 450 | ... | 13·1 | ... | 82·9 |
| Markets | ... | ... | 941 | ... | 3·5 | ... | 96·5 |
| H. M. Customs | ... | ... | 1,524 | ... | 56·8 | ... | 43·2 |
| Government Granaries | ... | ... | 184 | ... | 58·7 | ... | 41·3 |
| Grain ships in harbour | ... | ... | 662 | ... | 98·3 | ... | 1·7 |

In interpreting these percentage figures it should be remembered that the gross flea index of the more congested districts, such as St. Paul's, is about 30 per cent. higher than that for more spacious regions, such as Kollupitiya. The Pettah figure is very close to that obtained in 1922-24. The Fort shows a marked increase in the relative number of *cheopis*. There are distinctly fewer *cheopis* in the Markets (Nagalagam street and Dean's road area), but though *cheopis* prevalence on the whole is lower numerically, *X. cheopis* is more widely diffused in both Kotahena and Wellawatta as judged by ratio of premises infested to premises trapped.

The detailed analysis of this survey and of the results yielded by grain ships in harbour will be discussed in a subsequent report.

The writer attempted in his memoir on the Parasitology of Plague to indicate the more important fallacies inherent in the execution of rat-flea surveys and the interpretation of the results obtained. During the year a copy of a report by Professor Ricardo Jorge on rats and fleas in relation to plague was received at the laboratory. This report reviews the evidence available at the International Health Office in Paris on a world-wide basis. In discussing the writer's memoir it is suggested that the Colombo findings are difficult to reconcile with those obtained in the United Provinces. But the writer has pointed out in several of his published papers, including the memoir commented on by Professor Ricardo Jorge, that the epidemiology and parasitology of plague in the Indo-Gangetic plains is not comparable with that of the maritime regions of the East Indies. As the writer pointed out in 1923 in an address to the Royal Society of Tropical Medicine, it is improbable that the flea species factor is of paramount importance in the plains of Northern India, where plague is epidemic, as he believes it to be in the maritime plague endemic or plague free regions of India, Burma, and Ceylon.

The results of recent research in malariology will serve to illustrate the point. Gill and others have found that the distribution of the various species of anopheline mosquitoes is not an important factor in the spread of malaria in the Indo-Gangetic plains. These plains are subject to terrible epidemics of both plague and malaria. At least four effective malaria-carrying mosquitoes are widely distributed through them and the rat-flea *X. cheopis* is present in sufficient abundance almost everywhere to initiate a plague epizootic.

By contrast let the south-western wet zone of low-country Ceylon be considered. Efficient malaria-carrying mosquitoes are not habitually found, but one particularly dangerous species, *A. culicifacies*, sometimes appears near breeding-places of a special type, *e.g.*, abandoned quarries. The evidence so far collected by Mr. Carter shows that it is here, in the vicinity of these breeding-places, and here alone, that outbreaks of malaria occur so far as this Province is concerned. In other words, malaria in this region is governed by the mosquito-species factor just as the spread of plague is governed by the rat-flea species factor, the flea being *X. cheopis* and the particular breeding-place grain stores, and both malaria and plague can be controlled by concentrating appropriate anti-larval or anti-rat and flea measures on the foci of the carrier-insect.

It is becoming increasingly clear that the importation of quite a few infected *X. cheopis* in grain or other vehicle into a zone of territory where such fleas as *X. astia* or *C. fasciatus* are indigenous may suffice to initiate an epizootic, and that under these circumstances the less efficient carrier may temporarily enter into play. Unless *X. cheopis* becomes established on the local rats, such outbreaks will be sporadic and there will be no tendency for the disease to spread into neighbouring territories where *X. cheopis* is entirely absent. The recent sporadic outbreak of plague at Dehiowita and many small outbreaks in Colombo itself exemplify this point.

The impression seems to be gaining ground that the *astia-cheopis* question will be completely solved by laboratory transmission experiments. Now in practice it is almost impossible to represent natural conditions in the laboratory. To take another example from malariology, several species of anophelines, *e.g.*, *Anopheles subpictus*, are readily infected with *Plasmodium vivax* in the laboratory, but they do not transmit the disease in a state of nature, save under exceptional circumstances.

Exact comparative studies of the transmitting powers of *X. astia* and *X. cheopis* under different climatic conditions are of considerable scientific interest and may turn out to have epidemiological value, especially if "blocked" fleas of each species are studied individually. But the relative roles of insects as carriers of disease depend on obscure specific differences in bionomics which can only be disclosed by the most exhaustive research both in the field and the laboratory. The plague-carrying power of the individual rat-flea of a particular species is only one of many factors to be considered by the epidemiologist. The specific flea population entering into transmission is at least as important.

A comprehensive study of the bionomics of rat-flea species should logically precede experimental studies of their relative transmitting powers.

Attention may be called to the paper by Armath Goyle which appeared in the Indian Journal of Medical Research for April, 1928, Vol. XV., p. 837. The comparative transmission experiments carried out with *X. astia* and *X. cheopis* at Lucknow confirm the writer's finding that *X. cheopis* is the superior vector of plague between rodents in the laboratory and that the relative plague transmitting power of the two fleas varies with the climatic conditions.

PLAGUE AND GRAIN.

Chalmers Granaries.

Experiments were conducted during the year on the movements of rats between the compartments into which each granary is subdivided. For this purpose active rats were released in the empty compartments after shutting the doors. They made a vertical ascent of the concrete walls at the corner of the granaries with astonishing ease and some were even able to scramble up several feet of plain rough concrete wall. The interior gutter pipes present in some granaries also acted as a rat ladder. Having ascended to the top of a partition wall the descent to the rice bags on the other side was easy.

Later in the year the granaries were improved by rendering each wall for a distance of three feet below the top to a perfectly smooth surface with cement. A six-inch smooth red band was run round the lower limits of this rat glacis. Instructions have been issued that rice bags are not to be piled higher than the red band.

The improved granaries were again tested by the writer, who was able to assure himself that no rat could surmount the smooth surround and so attain the next compartment. The down pipes have also been rat-guarded and the doors improved. The position now is that if a rat should gain access to the interior of one particular compartment it cannot escape therefrom unless the door be opened, so that when a compartment is emptied and the last pile of bags removed it is possible to get at the rats and destroy them. Formerly if plague broke out among a colony of rats in one compartment and attempts were made to kill the still surviving rats, the sole result was to spread the infection into the neighbouring sections of the granary. It should now be possible to isolate any rat colony and keep the total rat population of the granary under control.

It is hoped to review the whole question of the transference of plague through the medium of grain and other channels in the next annual report. A large amount of data have already been collected. It will suffice for the present to point out that the Chalmers Granaries at present are not "rat-proof" and cannot be made so without very costly alterations; they can, however, be kept reasonably "rat-free" if well administered.

RAILWAY GOODS SHEDS.

During the year under review a Committee was appointed by Government to consider the rat-proofing of railway goods sheds, in some of which a considerable amount of grain and other materials attractive to rats are stored pending transportation by rail. The writer represents the Council on this Committee whose proceedings are not yet terminated. Model plans and specifications for railway goods sheds have been drawn up in consultation with the Government Sanitation Engineer, the Assistant Director of Sanitary Services, and the Ways and Works Engineer, Ceylon Government Railway.

FUMIGATION EXPERIMENTS.

A series of laboratory experiments on the fumigation of a small grained rice with cyanide gas was commenced in November, 1928, with the object of ascertaining the extent and rapidity with which the gas would penetrate into the interior of a bag of grain.

Rat fleas and their eggs were placed in tubes of glass or fine wire gauze open at one or both ends and loosely plugged with cotton wool. These test tubes were inserted at various depths in the bag from just beneath the surface to the central axis. The bag itself was placed in a galvanized iron bin with tight-fitting lid and samples of air were drawn off from the bin by an aspirator through dilute caustic potash solution for estimation of the cyanide content by the orthodox silver nitrate method. The hydrogen cyanide gas was generated by two methods, either by running sulphuric into sodium cyanide solution or by sprinkling a rapidly weighed amount of calcium cyanide "A" dust into the bin. The results of the two most instructive experiments may be summarized here. It was found that a concentration of 150 parts of H.C.N. per 100,000 of air sufficed to kill all the fleas close to the gunny bag after 15 minutes' exposure but those in the central axis survived. Moreover, some of the lateral eggs developed into larvae. All fleas and eggs in all parts of the interior of the bag from the periphery to the central axis were killed when a concentration of 200 parts of hydrogen cyanide and an exposure of 45 minutes was reached.

During the current year a series of experiments on the fumigation of rice in barges or lighters with the Liston Cyanide Fumigator were carried out in the harbour. The whole subject of fumigation of grain will be dealt with in detail in a future report. It may be said here that complete penetration of 200 closely stocked rice bags was obtained in $2\frac{1}{2}$ hours with a concentration of hydrogen cyanide lethal to fleas. It would seem probable, however, that between $2\frac{1}{2}$ to 3 hours' exposure to a high concentration of cyanide will be required to completely disinfest a barge holding 1,000 bags of rice. In practice nearly all the fleas are found in or among the strands of the gunny bags and in the surface layers of the grain. It is possible therefore that the time required might be shortened considerably for routine plague preventive purposes. Further experiments are in progress on other methods of rice fumigation with cyanide gas.

The writer has been present at several conferences and departmental discussions of the grain fumigation question during 1928. The co-operation of distinguished experts in Great Britain has been enlisted. All the alternative means of solving the problem are being explored. The practical difficulties in the way of effectively fumigating *all* the grain, amounting to about ten million cwts. annually, are very great. They can certainly be overcome, but, probably, only at considerable cost. Meanwhile fumigation in lighters, though it may involve delay where considerable quantities have to be dealt with within a day, is available for dealing with consignments judged to be specially dangerous *qua* plague.

The danger would seem to vary according to the amount of plague infection in the port of origin, distance between port of origin and Colombo, and the rat and plague state of the ship. At present plague is at a very low ebb in the principal ports of the Orient and the danger of transporting the infection overseas is lower than it has been for years. It is impossible to say how long these favourable circumstances will continue. Meanwhile there is time and opportunity to consolidate the defences of the Colony against plague invasion.

RESEARCH REPORT ON THE COLOMBO WATER SUPPLY.

Colombo is supplied with water from an upland surface catchment area of 2,500 acres extent situated 28 miles by road from the City. The rainfall on this area averaged 166·69 inches for the decennium 1918-27, the minimum during this period being 127·05 in 1921 and the maximum 216·81 in 1923.

This fall is impounded in a reservoir formed in 1886 by building a dam across the narrow end of the valley formerly traversed by a tributary of the Kelani river.

The dam was raised from 60 to 71 feet above reservoir bottom in 1927 so that spill level of the 205-acre reservoir is now 373 feet above mean sea level and its total capacity 1,900,000.000 gallons.

Above water level the catchment area consists of steep hills covered with jungle, save for the two-chain clearing round the high water mark.

The subsoil is of cabook overlying gneiss. The reservoir is constantly fed by two large streams and intermittently by some sixteen small ones.

The water level is chiefly governed by the rainfall during the north-east monsoon. Thus the shortage of water in 1928, when level sank to 22 feet 10 inches below spill, was mainly due to the fact that only 26·3 inches fell during the monsoon of October-November, 1927, the lowest recorded since the dam was built, against an average of 51·18 inches for the 40 years 1887-1927.

The water is drawn off from a straining shaft fitted with a double series of gauze screens of 400 mesh copper and through reservoir sluices at 13, 25, 37, and 49 feet. It then enters a settling basin of 445,000 gallons capacity, whence it passes through fifteen 21-foot diameter Jewell low-type gravity filters to a clear water basin of 962,000 gallons from which it flows by gravity through two 20-inch cast-iron and one 30-inch steel main for 25½ miles to the two service reservoirs, each of 8,000,000 gallons capacity. The head of water at Maligakanda is 100 feet and at Elie House 95 feet.

COMPOSITION OF THE RESERVOIR WATER.

The chemical and microbiological state of the water is naturally subject to great variation according to rainfall and depth below surface.

The following figures were obtained by the City Analyst from a series of samples taken by the writer with a vacuum depth apparatus under dry weather conditions in March, 1926.

| PARTS PER 100,000 | | | | | | |
|---|-----|-----------------------|-----|----------|-----|---------|
| | | Surface 18 Inches. | | 24 Feet. | | Bottom. |
| Total solids and suspended matter | ... | 4·0 | ... | 5·0 | ... | 6·0 |
| Total solids in solution | ... | 4·0 | ... | 4·0 | ... | 4·0 |
| Suspended matter | ... | Nil | ... | 1·0 | ... | 2·0 |
| Free ammonia | ... | Nil | ... | 0·020 | ... | 0·040 |
| Albuminoid ammonia | ... | 0·006 | ... | 0·010 | ... | 0·014 |
| Chlorine | ... | 0·6 | ... | 0·6 | ... | 0·8 |
| Nitrates and nitrites | ... | 0·08 | ... | 0·12 | ... | 0·1 |
| Nitrites | ... | Nil | ... | Trace | ... | Trace |
| Oxygen consuming power in 2 hours at 31°C | ... | 0·0768 | ... | 0·155 | ... | 0·157 |
| Total iron as Fe. | ... | 0·0888 | ... | 0·1739 | ... | 0·3902 |
| PARTS PER MILLION. | | | | | | |
| Dissolved Oxygen at 31°C. | ... | 6·4 | ... | 4·22 | ... | 2·16 |

After heavy rain on a dry watershed quantities of organic debris are swept into the lake together with ferruginous washings from the laterite soil.

The water is remarkably soft. Thus on September 2, 1920, the reservoir water showed only 0·64 parts per 100,000 of lime as calcium carbonate.

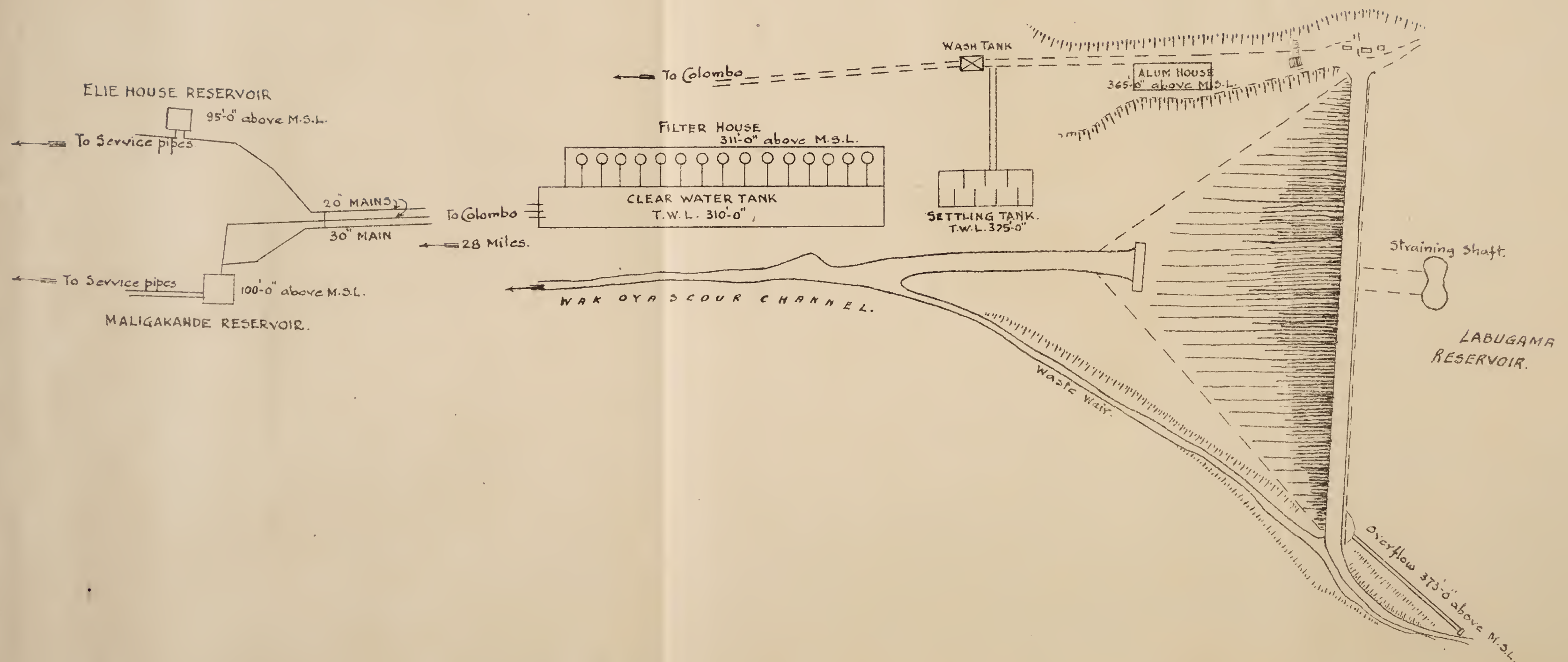
Under dry weather stagnant conditions a brown ferruginous tint develops, increasing steadily according to depth. In one observation with a field tintometer and the usual standard discs the colour increased from 6 at the surface to 65 in a sample drawn from the bottom by a vacuum apparatus. A bottom sample of this type may show as much as 0·8 parts of iron per 100,000, most of which, however, speedily deposits as ferric hydrate when the water is brought into contact with air, simultaneously there is a deepening of tint. Acidity as measured by hydrogen iron concentration also increases with depth, the Ph figures corresponding to tints 6 and 65 being 6·2 and 5·6. There is a corresponding decrease in dissolved oxygen from full saturation at surface to a state of practical anærobiosis towards bottom (60-70 feet) under extreme dry weather conditions. At such times a marked odour of sulphuretted hydrogen may be discerned in the straining shaft.

Biology of the Colombo Water Supply.

A great variety of flora and fauna are found in the waters of the Labugama lake. No attempt has been made at a comprehensive study of these forms from a general biological standpoint. In what follows attention will be directed to those species which are of hygienic or economic significance in waterworks practice. As Kirkpatrick points out in a bulletin issued by the British Museum, the biology of waterworks in the broad sense is practically co-extensive with that of fresh water animals and plants.

The various organisms will be briefly dealt with in descending order of complexity: fauna first and then flora.

SKETCH PLAN OF LABUGAMA WATER WORKS.



DAMBORE

PLAN OF LABUGAMA CATCHMENT AREA

CHS: 10 5 0 10 20 30 40 50 CHS:

SCALE, 16 CHAINS = 1 INCH

MAPOTTA

WEYMOUTH

RESERVED

LABUGAMAKANDA

MADAKADA

MORIANKANDA

WAVILLA

KARANDANA

TIKPOLAHENA

HANDUGALAKANDA

MAPOTE

Supdt Bungalow
Shed
Cooly Lines
Shed
Wash Tank
Alum House
624
ERATNADENIYA
Clear Water Basin
Filter House
Settling Tank
Straining Spout
Engineers Bungalow

670
TUTTIRIPITIYA

809
ELAWALKANDA

1497

1,151

Pisces.

In pre-filter days small fish formerly gained frequent access to the main supply through imperfections in the copper screens. Even now that the whole supply is constantly filtered and the screens repaired, fish of some size, such as *Pontius filamentosus*, are occasionally found in the service reservoirs. Fish in any quantity are objectionable in a piped supply. The smaller varieties are apt to block water mains. Death of the fish in any situation leads to decomposition and a taint in the water.

Insecta.

Culicid larvæ of the genus *Chaorobus* have several times been observed burrowing in the surface layers of the sand of the rapid mechanical filters, tending thereby to some disturbance of filtering efficiency. In the case of rapid mechanical filters subject to daily washing such disturbances are of purely temporary nature.

In September, 1920, the walls at the entrance of the settling tank and of the main supply pipe to the filter house were found to be covered with a continuous layer formed of the tubular sheaths of the caddis fly larva (trichoptera.) The tubules contained myriads of living larvæ. No ill effects need be feared from this type of growth in the ordinary course of events. A sudden change in the quality of the water or chemical treatment may lead, however, to the sudden death of these masses of larvæ and to pollution of the water with the products of their decay. The growth is readily removed by scraping.

Crustacea.

Various species of Cladocera and Copepoda are common in the raw water and a species of *Gammarus* is apt to appear in the piped supply, particularly under drought conditions when little water can be spared for flushing. The *Gammarus* being a conspicuous object attracts consumers attention and sometimes gives rise to needless alarm. Individually, such organisms are harmless hygienically. Occasionally, however, such crustaceans as *Daphnia pulex* appear in waterworks in enormous numbers and may then be a source of considerable trouble by clogging the screens.

Polyzoa.

The following two species have been observed :

- (1) *Fredericella indica* (Annandale).
- (2) *Plumatella longigemmis* (Annandale).

Before the installation of the rapid mechanical filter plant, polyzoa played an important part in the hygiene and general economy of the Colombo water supply. Their growth on the walls of waterpipes contributed considerably to the obstruction in the flow of water through the mains. Prior to 1917 masses of a moss-like growth, sometimes as big as a hen's egg, could frequently be seen passing over the spill into the Maligakanda service reservoir. These usually consisted of the *Fredericella*, but sometimes the *Plumatella* appeared. *Fredericella indica* was identified by Sir Sidney Harmer, F.R.S., from specimens sent by the writer. *Plumatella longigemmis* was identified by Annandale from specimens sent by the writer *via* the British Museum. This species had only been observed once before, viz., in slightly brackish water in an island in the Chilka lake on the east coast of India. *Fredericella* grew freely on the interior walls of the three-inch experimental pipe set up in the laboratory in 1913 for the study of the mode of formation of the incrustation of the water mains. Town water was caused to pass through this pipe at a slow and uniform rate.

On April 17, 1920, masses of *Plumatella longigemmis* appeared on the filters at Labugama. The level of the lake was rising rapidly from an exceptionally low level after heavy rain. The same species in a partial state of decomposition was recovered in August, 1920, from the side walls and bottom of the wash water tank. The polyzoa mass formed a continuous layer below water level. Entangled in the animal moss were larvæ of *Chaorobus*, and oligochaete worms, the zooary showed numerous attached vorticella. More frequent cleansing of the tank has obviated a reappearance of this species in this situation whence it could readily infect the whole body of the filter and eventually the whole supply. A similar appearance was noted in 1921 in the settling tank the walls of which were completely covered with this polyzoon.

Formerly fragments of polyzoa were familiar objects in the tap water. Nowadays they are only seen on those exceptional occasions when, owing to repeated choking of the filters by extraordinary quantities of plankton or other cause, the bye-pass to the filters has to be opened.

The polyzoa are an isolated class of animals. The two species in question are of colonial habit and belong to the family known as the Phylactolaemata.

The zooid take the form of a tree of animal tissue with a distinct animalcule (polypide) enclosed in each branch. Each polyp is complete in itself and is enclosed in a transparent membranous sac ; it is provided with a simple type of alimentary canal, and the rudiments of a nervous and muscular system ; there are testes and ovaries, but no vascular system. Each polyp has its special apparatus for capturing food consisting of a disc or lophophore at the outer end of the body. This disc is surrounded by a ring of tentacles and is protruded from time to time from the open end of tubular case which shelters the polyp.

The tentacles themselves are mobile and are covered with mobile cilia. Their combined movements set up a current in the water towards the mouth which is situated immediately beneath the lophophore. Bacteria and minute plankton forms are thus engulfed and assimilated.

Reproduction may occur in three different ways: asexually, by budding of polypides, or by a special resistant type of internal bud known in the case of the Phylactolaemata as statoblasts ; sexually, by eggs. The polypides are hermaphrodite, but the ova are probably fertilized by the spermatozoa of different individuals.

Seasonal changes exert a strong effect upon many species of polyzoa. In Europe the polypides usually die at the approach of winter ; in India, on the other hand, towards the onset of the hot weather. At this stage, every branch of the partially disorganized zooary of *Plumatella* or *Fredericella* will be seen to be occupied by the dark coloured oval statoblasts which are destined eventually to give rise to a new zooid when favourable conditions return.

The statoblasts are conspicuous and characteristic objects adapted to enable the organism to survive a spell of unfavourable conditions.

Plumatella statoblasts are provided with air cells. The writer has seen quantities of them floating on the surface of unfiltered Colombo tap water.

This seasonal habit of polyzoa may be a cause of much trouble in unfiltered supplies. The formation of statoblasts or winter buds is frequently accompanied by death and whole sale decomposition of the whole zooid mass. De Vries gives an instance in which such polyzoon disintegration fouled the water so badly that even horses could not be induced to drink it. Polyzoa have frequently been known to cause serious trouble in waterworks owing to the blockage of small pipes, ball taps, and strainers of meters by fragments of growth broken off from the main mass. The polyzoon colony acts as a nidus for a great variety of plankton species. In the Colombo supply both rotifers and vorticellae are frequently seen attached to the zooid. The polyps feed on bacteria as well as other minute micro-organisms, and in this respect are beneficial ; but on the other hand, the products of their death and decay lead in turn to a great increase in bacterial numbers.

Fortunately, the remedy for all this is quite simple : in one word, filtration. Polyzoa are large animalculae. Even the statoblasts of the Colombo species are readily visible to the naked eye. They are arrested by the roughest and most rapid type of mechanical filter. Moreover, filtration removes the micro-organisms on which polyzoa are dependent for food. Hence in every recorded instance where filters have been installed and efficiently worked, polyzoa have promptly disappeared from the water supply.

It will be noted however later on that a few statoblasts have been observed in the deepest layers of a sectioned sand filter. They were probably derived from the infected wash water tank already mentioned.

Annandale has recorded the presence of polyzoa in the waterworks of Kyoto, Japan (*Paludicella*). *Plumatella emarginata* occurs in the Rangoon supply. An account of European and British instances of a similar kind will be found, in an article on the polyzoa of waterworks by Sir Sidney Harmer, F.R.S., in the Proceedings of the Zoological Society, 1913.

Fungi.

A variety of fresh water fungi may be seen in the filter bed plankton. A species of *Saprolegnia* has been observed on the crust of the experimental pipes in this laboratory. This family of fungi is parasitic or saprophytic on aquatic animals and plants. One species is said to be the pathogenic agent of salmon disease. Certain species of *Saprolegnia*, such as *Leptomitius lacteus*, appear to be common in sewage polluted streams in Britain. The sheaths of the filaments of both the *Saprolegnia* observed in the Colombo supply and of *Leptomitius lacteus* have a decided affinity for oxide of iron. Hence when present in abundance they may play a part similar to that of iron bacteria in the production of incrustations on the walls of pipes.

The presence of moderate numbers of fungi has no special significance in the hygiene of water supplies. Great abundance would indicate an excess of organic matter in the water in which they grow.

Sulphur Bacteria.

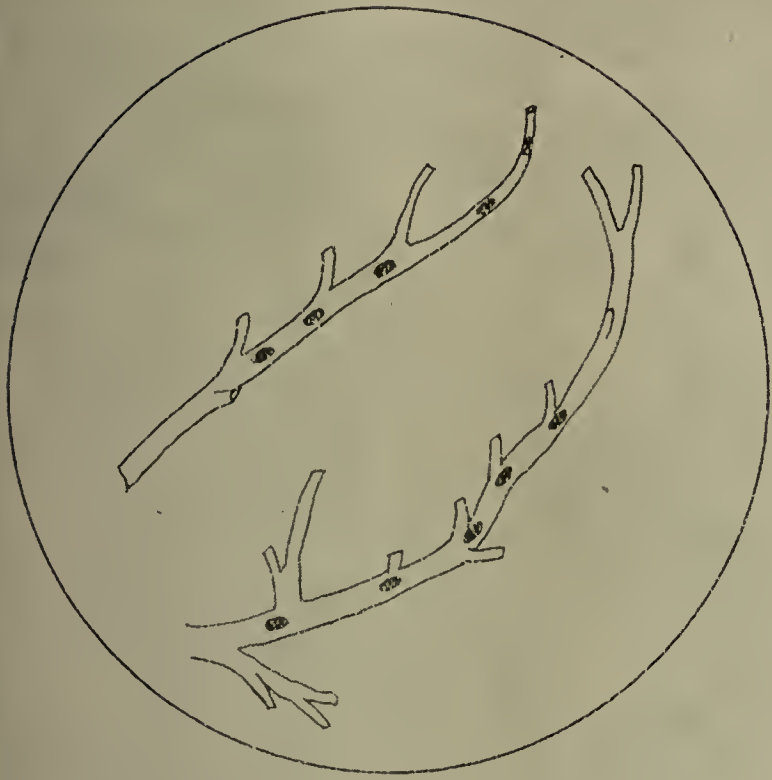
As already noted, an odour of sulphuretted hydrogen is sometimes discernible arising from the depths of the straining shaft. At the bottom of lakes or at levels where there is a marked deficiency of oxygen a great variety of bacteria appear to have the power of breaking down protein and other sulphur containing organic compounds and even soluble sulphates, with evolution of sulphuretted hydrogen gas. The gas thus generated serves as a source of energy to the sulphur bacteria which, according to Winogradsky, have the power of taking up H_2S and oxidizing it with the production of sulphur and water. *Beggiatoa alba*, a well known sulphur bacterium, showing numerous sulphur globules in the protoplasm of its motile filaments, has been observed in the filter plankton at Labugama. These bacteria appear to inhabit a definite layer of water of varying depth, obtaining oxygen from above and H_2S from below. In all probability the whole sulphur cycle of organic nature is illustrated at Labugama. Further research would very likely disclose the presence of such organisms as *Thiobacillus denitrificans*, Beijerinck which has the power of oxidizing the sulphur and sulphuretted hydrogen produced by the sulphur bacteria to sulphates in presence of nitrates ; while in the slime at the bottom of the lake there are probably anaerobic bacteria of the type of *Spirillum desulphuricans*, Beijerinck, which have the power of breaking up these sulphates with H_2S production as above.

Iron Bacteria.

Many organisms can take up iron from a water in which they live and deposit it as ferric hydroxide in their mucilaginous sheaths ; amongst these organisms are the iron bacteria *sensu strictu*, but various species of Cyanophyceae, Chlorophyceae, and Fungi have the same faculty.

The morphology of the iron bacteria is more highly differentiated than that of most of the Schizomycetes and approximates to that of the lower Fungi.

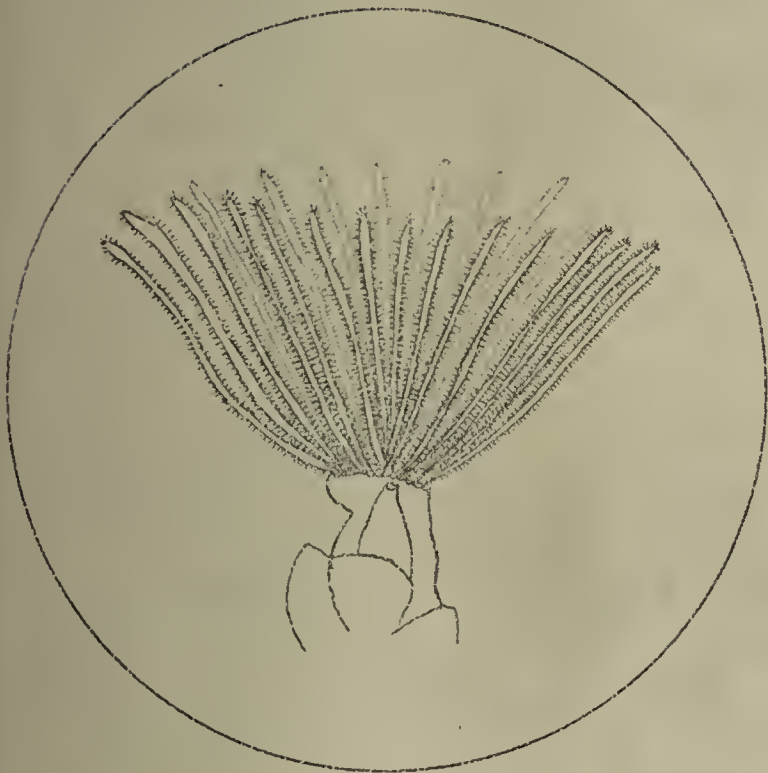
Leptothrix ochrea, Kützing, the most widely distributed of all known species of iron bacteria, was first recorded from Ceylon by Molisch ; it has been identified in scrapings of experimental pipe incrustation sent home by the writer by Prof. David Ellis, the author of the well known book on Iron Bacteria and by Mr. Hodgetts of Birmingham University. Its typical form is that of a tubular thread of very variable length without transverse septa. The mucilaginous external layer is typically marked out with a rusty deposit of iron.



(1)
x 3



(2)
x 40



(3)
x 75



(4)
x 350

Polyzoon *Fredericella Indica* (after Annandale).

Iron bacterium *Leptothrix ochrea* (after Ellis).

(1) Outline of zoarium containing statoblasts.

(2) Statoblast.

(3) Outline of expanded lophophore.

(4) Bacterial filaments.

The writer has also observed tangled non-septate filaments closely resembling *Spirophyllum ferrugineum* Ellis and more rarely forms similar to *Gallionella ferruginea* Ehrenberg. The former resembles a spirally twisted band, the latter a twisted thread. Ellis has put forward the view that the three species are in reality pleomorphic forms of one and the same organism since they are constantly associated together in nature and have a similar mode of reproduction.

An organism similar to, if not identical with *Crenothrix polyspora* has been frequently observed in the plankton film on the filters. This well known iron bacterium has attracted more attention than any other on account of the calamitous rapidity of its growth in certain water supplies. It has been known to turn a bright clear potable water into a reddish brown offensive and sometimes undrinkable fluid within a few days. The Berlin crenothrix water calamity happened in 1878, that at Rotterdam in 1874, that at Cheltenham in 1896.

Chromophilic Bacteria.

The following are the chief characters of three common bacteria in the Colombo supply which produce conspicuous pigmented colonies on agar plates. The specific names represent the most closely allied species described in Bergey's Manual of Determinative Bacteriology.

Chromobacterium violaceum, Bergonzini. Slender actively motile rods; nonsporing; gram negative; colonies on agar semi-transparent at first, smooth, circular, deep violet pigmentation after several days growth; acid in glucose broth but not in lactose; slight trace of indol in peptone water; trace of nitrites in nitrate broth; turned milk alkaline with violet pellicle; liquefied gelatin. Agar slope, gray to deep violet, broth turbid with violet pellicle, potato deep violet layer. According to Bergey this species does not form indol or reduce nitrites.

Cunningham and Raghavachari (Indian Journal of Medical Research, Vol. XI. p. 1285, 1924) state that several violet producing organisms suddenly appeared in three separate water supplies in the Madras Presidency. No such organism had been noted in these writers' 16 years' previous experience of the Presidency water supplies. After their first appearance violet colonies were constantly observed in every sample examined of the waters concerned. Only one Colombo strain has been studied in any detail; its characters agree well with Madras strain C. save that a trace of indol is formed (5 days in bacto-peptone water).

Flavobacterium lutescens, Lustig. Small non-motile rods; non-sporing; gram negative; colonies on agar smooth circular, lemon coloured; no acidity in glucose or lactose; indol produced in peptone water; nitrates not reduced to nitrites; litmus milk turned alkaline; gelatine liquefied; agar slope lemon coloured; broth, general turbidity, yellow deposit; potato lemon to orange pigment.

According to Bergey, indol is not formed and nitrates are reduced to nitrites.

Serratia amyoloruber, Hefferan. Small actively motile rod; non-sporing; gram negative; colonies smooth, round, elevated, pigment orange red, no gas in carbohydrate media; indol not formed, nitrates not reduced to nitrites; agar slope orange red glistening growth; broth reddish turbidity and deposit, potato orange red pigment; gelatin liquefied, blood serum liquefied.

The Colombo strain agrees with the text-book description of an organism isolated from the Mississippi river, except that nitrates were not reduced to nitrites in one week.

Miscellaneous Water Bacteria growing on Agar.

Some years ago much attention was paid to counts of the number of organisms growing in plates of plain culture media inoculated with measured volumes of water. Thus, according to Mignel a water was ranked as pure if the count was less than 100 per c.c. and very impure if it exceeded 10,000.

In actual practice the counts obtained from a given water vary enormously according to the constitution of the culture medium, its precise reaction, the temperature and period of incubation, the depth to which the plates are poured and other variable factors.

In a state of nature the bacterial content of a water is never in a state of equilibrium. Take Labugama lake as an example; showers of rain wash organic matter and the faecal dejecta of animals containing myriads of microbes into the lake; during periods of drought the water undergoes self-purification owing to the continued influence of storage, sunlight, and sedimentation. The storage effects are themselves biological and extremely complex and involve a diminution in the amount of foodstuffs available for bacterial growth.

In dry weather the general colony count on agar falls very greatly, especially in those surface layers where tropical sunlight exerts its maximum disinfecting effects. On March 26, 1920, the agar colony count of the water at the 13-foot draw off averaged only 1 per c.c., the water level being only a few feet above the sluice. On September 10, 1928, it was only 9 per c.c. after 48 hours at 37°C. In wet weather the corresponding count of the water passing into supply may exceed 500 per c.c. (693 on November 6, 1913.) See also the typical results of the bacteriological examination of Labugama lake water shown in Tables IV, and VI. The counts tend to increase to about 24 feet and then to diminish again at the lowest levels where anaerobic conditions tend to prevail; they were made with a beef extract medium containing 1 per cent. Witte's peptone before the war and the same amount of Digestive Ferment Co.'s Bacto-peptone and beef extract of recent years. The composition and the quantity of medium and the size of the plates (four inches) are kept constant and all counts are made in plates inverted on blotting paper in the incubator after 48 hours at 37°C. If the covers are kept on the colonies of certain bacteria tend to spread and obscure the others. Various fractions of a cubic centimetre are used and plates counted showing not more than 300 colonies.

If the same technique is uniformly employed sufficiently comparable results can be obtained from the plain agar counts to be of practical value as a rough indicator of the amount of bacterial life the water can support under the given conditions: a high count usually means excess of organic matter in the water. Thus if the water mains are not flushed for some time owing to drought or a tank in the waterworks is not cleaned periodically so as to remove the organic growth on their walls, the colony count will rise.

In Europe it is usual to count at 20°C. in a gelatin medium and 37°C. in agar. Gelatin, of course, cannot be used in Colombo except in the special low temperature incubator and nothing would be gained by counting at a temperature never reached in practice. The highest counts from Colombo water are attained at room temperature (about 28°C), but blood heat is employed as a routine since it favours the growth of excremental bacteria relative to the less significant species of water bacteria.

Plankton.

A great variety of microscopic plants and animals (plankton) occur in the Colombo water supply.

These plankton forms have been studied in collections from three sources: (1) The deposit isolated with the Sedgwick Rafter apparatus by means of which a definite volume of water is filtered through a sand trap and the organisms arrested in the sand, and then washed into a small unit volume of water for observation and counting. (2) Plankton washed out of the surface layers of the sand of the mechanical filters. (3) Scrapings from experimental pipes used for the study of the incrustation of the water mains.

Observations of the first type have been made at irregular intervals. They show a comparative scarcity of plankton forms in the general body of the lake water. Thus on November 13, 1923, there were about 20 *Peridinium*, 10 *Staurostrum*, 10 *Nitzschia*, and 5 *Cosmarium* per c.c. of the water at level of draw off (11 feet).

The most complete information available is derived from the results of the systematic examination of filter sand plankton sent by the writer to the Royal Botanic Gardens, Kew, and thence at the instance of Sir David Prain to the well known algal expert, W. J. Hodgetts, M.Sc., of the University of Birmingham.

The results shown in his valuable report are summarised below.

The Chlorophyceae (green algae), Conjugatae (Desmids), Heterokontae, Cyanophyceae (blue green algae) and the diatoms belong to the vegetable kingdom. The flagellatae are animals (Protozoa). These marked with an asterisk were also found in scrapings or washings of Colombo experimental pipe incrustation examined at Birmingham.

CHLOROPHYCEAE.

ORDER: Protococcales.

1. *Glococystis gigas* (Kütz.) Lagerh. Very rare.
2. *Ankistrodesmus spiralis* (Turner) Lemm. Abundant and well-developed.
3. *A. falcatus* (Corda) Ralfs.
var. *spirilliformis* G. S. West (Brit. Freshw. Alg., 1904, p. 224). Common.
var. *acicularis* (A. Br.) G. S. West (Brit. Freshw. Alg. 1904, p. 223). Not uncommon.
var. *mirabile* (W. & G. S. West) G. S. West (loc. cit. 1904, p. 224). Not uncommon.
4. *Scenedesmus quadricauda* (Turp.) Bréb.
var. *typicus* Brunnthaler. Rare.
5. * *Tetraëdron regulare* Kütz. Rare.
6. * *T. caudatum* (Corda) Hansg. var. *incisum* Lagerh. (Susswasserfl. Deutschl., &c., Heft. 5, 1915, p. 151.) Rare.
7. *T. Moebiusi* Brunnthaler (Süssw.—Flora Deutschl., &c., Heft. 5, 1915, p. 154). Only one individual seen. Hitherto recorded only from Australia. Very rare.

ORDER: Volvocales.

8. *Chlamydomonas* Sp. The nature of the chloroplast could not be determined.

ORDER: Conjugatae.

Fam. Desmidiaceae.

9. *Penium Libellula* Nordst. var. *intermedia* Roy. & Biss. (In Ann. Scot. Nat. Hist., 1894, p. 252.) Previously recorded from Ceylon by W. & G. S. West. (Trans. Linn. Sec. Bot. VI., 1902 p. 136.) Very rare.
10. *Closterium gracile* Bréb. Not uncommon. Var. *tenue* (Lemm.) W. & G. S. West. Rare. Both the type and this var. previously recorded from Ceylon by W. & G. S. West, loc. cit. p. 138.
11. *Cosmarium depressum* (Näg.) Lund. (W. & G. S. West, Brit. Desm. II. p. 176, Pl. 62, fig. 3.) Very rare.
12. *Cos. abbreviatum* Racib. (W. & G. S. West, loc. cit. III., p. 84, Pl. 72, fig. 11.) Very rare.
13. *Cos. subtumidum* Nordst. forma. A small form. Very rare.

14. * *Cos. Regnesii* Reinsch. forma. Frequent.
15. *Cos. moniliforme* (Turp.) Ralps. forma. *panduriformis* Heimerl. (W. & G. S. West, loc. cit. III. p. 22, Pl. 67, fig. 8-9.) Rare.
16. *Cos. globosum* Bulnh. var. *minus* Hansg. (Prodr. Algenfl. Böhm. 1888, p. 243.) Very rare.
17. * *Staurastrum brachiatum* Ralfs. (Brit. Desm. 1848, p. 131, t. 23, f. 9.) Rare.
18. * *St. jaculiferum* W. West, forma *quadriradiata* W. & G. S. West (Journ. Linn. Soc. Bot. XXXV., 1904, p. 543.) Rare.
19. * *St. tertracrum* Ralfs. (Brit. Desm. p. 137, tab. 23, f. 7.) Common.
 * var. *evolutum* W. & G. S. West (in Trans. Bot. Soc. Edinburgh, Nov. 1904, p. 25, ex. Pl. II., f. 31). Common.
 * var. *undulatum* W. & G. S. West (in Trans. Linn. Soc. Bot. V. 1895, p. 80, Pl. IX., f. 6). Frequent.
20. *St. excavatum* W. & G. S. West (in Trans. Linn. Soc. Lond, Bot. V., 1895, p. 78, Pl. VIII., f. 42). Rare.
21. * *St. aristiferum* Ralfs var. *planum* W. B. Turner (Freshw. Alg. E. India, Kongl. Vet. Akad. Handal Bd. 25, 1892, No. 5 p. 106, tab. XVI., f. 32). Rare.
22. * *St. fissum* W. B. Turner (loc. cit. p. 110, Pl. XIV., f. 24). Very rare.
23. *St. aestrophorum* W. & G. West (in Trans. Linn. Soc. Bot. VI., 1902, p. 184, Pl. 22 f. 3). Originally described from Ceylon by W. & G. S. West with whose description the specimens observed agreed exactly. Very rare.
24. *St. unicorn* W. B. Turner var. *ceylanicum* W. & G. S. West (Trans. Linn. Soc. Bot. VI., 1902, p. 176, Pl. 21, f. 16). A second record of this variety from Ceylon. Very rare.
25. *St. pseudosebaldi* Wille (Norg. Fersk. Alg. p. 45, t. II., fig. 30) forma. Rare.
26. *St. cyclacanthum* W. & G. S. West (in Trans. Linn. Soc. Bot. VI., 1902, p. 189, Pl. 22, f. 18). In size and form agreeing very well with the description of W. & G. S. West, but the vertical view was bi-radiate instead of tri-radiate. Only one individual was seen.
27. * *St. trifurcicatum* W. & G. S. West (in Trans. Linn. Soc. Bot. VI, 1902, p. 184, Pl. 22, f. 6). A second record of this species from Ceylon. The specimens observed were generally rather smaller than those described by W. & G. S. West. Rather rare.
28. * *Arthrodesmus triangularis* var. *subtriangularis* (Borge) W. & G. West (in Brit. Desm. IV., 1912, p. 100, Pl. 115, fig. 1-3). Frequent.
29. * *A. octocornis* Ehrenb. Frequent.
30. * *Sphaerosoma excavatum* Ralfs. var. *granulata* Rabenh. (Fl. Eur. Alg. III, p. 149.) There is considerable doubt about this determination as the specimens were observed only as isolated empty cells, never in the form of filaments. No species of cosmarium could be found in the literature which resembled it, although it may be a new species of this genus. Rather rare.

ORDER : Oedogoniales.

31. *Oedogonium minus* Wittr. (?) Only a few vegetative filaments of this species were seen. The cells had spirally disposed lines of granules as described for *O. minus*, but the cells were longer and narrower than those of this species, according to the description given by Hirn in his monograph of the Oedogoniaceæ (Acta Soc. Sci. Fennicæ, XXVII., No. 1. 1900, p. 151). Various other filaments of *Oedogonium* were occasionally seen, but since they were purely vegetative the various species could not be identified.

HETEROKONTAE.

1. *Botryococcus protuberans* W. & G. S. West (Trans. Roy. Soc. Edinburgh XLI., Pt. 3. 1905, p. 507, Pl. 4, f. 4, Pl. 6, f. 8-9). An interesting species originally described from Scottish plankton, while a small variety of it (var. *minor*) has recently been described by G. M. Smith from the lakes of Wisconsin, U.S. Rare.

CYANOPHYCEAE.

1. *Anabaena* sp. Filaments straight, no spores seen, cells globose. Heterocysts globose, Very rare.
2. *Aphanothece microspora* (Menegh) Rabenh. (Fl. Eur. Alg. II., 1865, p. 64.) Only one small colony seen.
3. *Tetrapedia glaucescens* Boldt. Seen only in the form of empty cells, but agreeing exactly in shape with this species.

BACILLARIALES (Diatoms.)

1. *Eunotia diodon* Ehrenb. Very rare.
2. *E. pectinalis* Kütz. Rare.
3. *E. lunaris* Grun. Rather rare.
4. *Cymbella ventricosa* Kütz. Rare.
5. *Gomphonema intricatum* Kütz. Very rare.
6. *Navicula* (*Neidium*) *affinis* Ehrenb. var. *minor* Cl. Very rare.
7. *N. pupula* Kütz. Very rare.
8. * *N. cryptocephala* Kütz. Common.
9. * *N. (Frustulia) rhomboides* Ehrenb. var. *saxonica* Cl. Rather common.
10. *N. (Frustulia) vulgaris* Thwaites. Very rare.
11. *N. (Anomoeoneis) serians* Bréb. var. *brachysira* (Bréb) V. H. Rare.
12. *N. (Pinnularia) Brannii* (Grunn.) Cl. Very rare.
13. *Stauroneis Phoenicenteron* Ehrenb. var. *genuina* Cl. Very rare.
14. *St. anceps* Ehrenb. Rare.
15. *Nitzschia vermicularis* Grun. Frequent.
16. *N. Palea* W. Sm. var. *major* Rabenh. Rare.

FLAGELLATAE.

1. *Dinobryon cylindricum* Imhof. Rare.
2. *Trachelomonas volvocina* Ehrenb. Rare.
3. *T. oblonga* Lemm. var. *punctata* Lemm. (in Süßw-flora Deutschl &c., Heft 2, 1913, p. 147). Very rare.
4. *T. hispida* (Perty) Stein. Very rare.
5. * *Peridinium inconspicuum* Lemm. (Süßwasserfl. Deutschl. &c., Heft 3, 1913, p. 42.) Frequent.
6. *P. cinctum* Ehrenb. (loc. cit. p. 46). Not uncommon.
7. *P. umbonatum* Stein, forma (?) (loc. cit. p. 39). This is probably a form or variety of *P. umbonatum*. The arrangement of the plates on the epivalve agrees exactly with this species, but the hypovalve differs in having (usually) five spines, while the postapical plates are somewhat unequal in size, whereas in typical *P. umbonatum* they are equal. In the hypovalve it somewhat resembles *P. marchicum* Lemm., but the arrangement of the plates of the epivalve is entirely different from what obtains in this species.

In addition to the above the following species of plankton organisms have been observed by Hodgetts in washings from the incrustation lining the experimental pipes.

DESMIDS.

1. *Arthrodesmus triangularis* var. *inflatus*. W. & G. S. West (in Brit. Desm. IV. 1912, p. 99, Pl. 114, figs. 14-15). Rare.
2. *A. bifidus* Bréb. Rare.
3. *A. Incus* (Bréb.) Hass. forma *minor*. W. & G. S. West. (Brit. Desm. IV., p. 92 Pl. 113. Figs. 16-19.) Rare.

CYANOPHYCEAE.

- Aphanocapsa elachista* W. & G. S. West var. *conferta*. (Journ. Linn. Soc. Bot. Vol. 40, 1912, p. 432, Pl. 19, f. 1). Very rare.

DIATOMS.

- Cyclotella Meneghiniana* Kütz. Very rare.
Stephanodiscus Hantzschii Grun. Only one seen.

When present in great abundance certain species of algae and protozoa have frequently been known to give rise to objectionable tastes and odours in water supplies. Thus the diatom *Asterionella* produces an aromatic odour when few in numbers and a fishy nauseating odour when very abundant. Waters rich in *Uroglena* have an odour resembling cod liver oil. *Synura* gives an odour of ripe cucumber. These odours appear to be due to the secretion of an essential oil by the organism. There is no evidence that these oily substances are injurious to health, but their sudden appearance in a water supply is apt to create much prejudice against the water and be a cause of complaint by consumers.

So far no serious troubles of this kind have arisen in connection with the Colombo supply; but it should be remembered that other supplies have remained free for long periods and yet have eventually suffered severely from a great multiplication of an odour-producing organism as a result of some obscure disturbance in the balance of nature in the reservoir. As a general rule the cleaner the watershed and the cleaner the reservoir, the smaller the risk of nuisance of this type arising. Hence the importance of taking precautions to reduce the amount of organic debris entering the reservoir by silt traps or other devices and of scouring or dredging accumulations of decomposing organic matter from the reservoir bed whenever opportunity arises.

According to Whipple, among the genera listed above, *Anabaena* has been known to produce a grassy and mouldy smell in water. When these organisms are very numerous they may produce an odour like raw green corn; *Dinobryon* may give a fishy smell like rockweed.

The plankton in the filter sand serves a useful purpose in adding to the efficiency of filtration. In fact when the filters are worked without a coagulant most of the filtration is due to the "skin" they form between the sand granules and the gelatinous coating they form round them.

Moreover, when growing on the surface of the filters in the presence of an ample supply of oxygen they are able to exert a decided purifying action on the organic matter in solution in the water as shown by a reduction in albuminoid ammonia and the amount of oxygen taken up from acid permanganate.

Faecal Bacteria.

Nowadays the hygienic quality of a water is judged on its content in bacteria of presumably faecal origin; especially the various types of *B. coli*. These organisms occur in enormous numbers in the intestines of man and all other mammalia and of fishes and birds also. Human excreta contain from 100 to 1,000 millions *B. coli* per gramme of faeces. Savage found 1 million *B. coli* per gramme in horse excrement, up to 10 millions per gramme for a cow, over 100 millions for a pig, and up to 100 millions for a sheep. Houston (1923) reported that the droppings of gulls frequenting the West Middlesex waterworks contained at least 10 million typical (lactose and indol positive) *B. coli* per gramme. Hence *B. coli* can be used as an *indicator* of the degree of faecal pollution of a water or food.

Streptococci and certain types of intestinal anærobes are also present in great abundance in the faeces of man and animals and their numerical estimation may be made to serve the same purpose as that of *B. coli* but, in general, much less conveniently.

Uncultivated faecal streptococci as a class have a very short life in water in the tropics. Hence the search for streptococci is useful as a confirmatory test of very recent pollution of a water. When circumstances point to an exceptionally dangerous or recent contamination, 20 c.c. of the water may be centrifuged at high speed and the deposit thus obtained plated out on Conradi-Drigalski plates.

Streptococci have been isolated in this laboratory on two occasions from the Colombo supply; once from the small stream entering the Labugama lake below the waterworks bungalow which drains a monkey infested block of jungle, and once in 1912 when the routine examination of standpipe samples disclosed an abnormal amount of *B. coli* as compared with the rest of the town water. The cause was traced to the accidental fracture of a water pipe in the neighbourhood of a sewer-laying trench. The precautions taken against this dangerous type of pollution have obviated a recurrence up to the present.

The special significance of the numerous types of streptococci has not been investigated in this laboratory. The writer is content to follow such authorities as Houston and Clemesha, whose experience indicates that in both temperate and tropic climes, the most common in the human intestine are those which ferment lactose, raffinose, salicin, and saccharose, but not mannite.

Clemesha only found streptococci on a few occasions in the course of his Indian studies on the bacteriology of water, principally in the grossly contaminated Hooghli river near Calcutta. He found experimentally that they died out with remarkable rapidity from waters to which they had been artificially added. He considers that it is of little use looking for streptococci as a routine as a negative result does not add much to our information and in cases of very gross pollution conclusive evidence can be obtained in the other more convenient ways presently to be described.

If milk be inoculated with a few cubic centimetres of a contaminated water and anærobie conditions be secured by pouring molten vaseline on to the surface of the mixture before incubation at blood heat, a characteristic change, commonly known as the "enteriditis" change, is usually produced, the vaseline is forced up the tube by gas formation, and the milk undergoes a stormy fermentation and is separated into shredded clot and whey. A positive result was formerly supposed to indicate the presence of *B. enteriditis sporogenes*, an anærobie bacillus described by Klein which, however, is, in all probability, a mixture of two different anærobes, *B. welchii* and *B. sporogenes*. In England the injection of "enteriditis" whey into a guinea-pig usually results in the death of the animal with characteristic lesions, but large quantities of such whey from milk inoculated with Labugama water have several times been so injected without ill-effect upon the pigs. The typical "enteriditis" change is usually due to *B. welchii* which is known to be very variable in its pathogenic powers. *B. sporogenes* digests milk. It would seem, therefore, that a non-pathogenic strain of *B. welchii* predominates in the intestines of the wild fauna of the Labugama watershed. It is hoped to follow up this point as opportunity affords.

Most faecal anærobie bacteria form very resistant spores. Hence their detection in a water gives no indication of date of pollution, which may well be very remote; for this reason this test is not employed as a routine in this laboratory.

It should be clearly understood that ordinary faecal germs do not necessarily produce any ill-effects on a consumer of a contaminated water, who must himself harbour millions of similar organisms in his own intestine, they are estimated simply and solely as a guide to the amount of faecal pollution present, past, and, therefore, probably future.

Moreover, the bacteria present in human excrement cannot be distinguished by any known test from those of the lower animals. Since birds, fishes, and domestic animals do not suffer, as far as is known, from water-borne diseases communicable to man the addition of their excrement to water has but slight significance. It is human excrement that is really dangerous, especially in the East, where apparently healthy carriers of the germs of dysentery and enteric are so numerous. If human excremental bacteria are allowed to gain access to a water supply, sooner or later than supply will become infected with the germs of either typhoid, dysentery, or cholera and give rise to a more or less widespread epidemic among the consumers.

The higher anthropoid apes can be infected with enteric and bacillary dysentery under laboratory conditions and as we shall see, certain other primates, especially the macaque monkeys, are under suspicion as carriers of amoebic dysentery. Subject to this qualification it may be said that the presence of faecal bacteria, particularly the more viable types of colon bacilli and streptococci, is an index of potential danger of water-borne disease if and when the water is exposed to pollution of human origin.

Fortunately the disease-producing bacilli likely to gain access to a water through the deposition of human faeces on a watershed *B. typhosus*, *V. cholerae* and bacilli of the paratyphoid and dysentery groups all die out rapidly in water, especially at tropical temperatures. Roughly speaking, in the tropics, if the faecal pollution is less than a week old the danger is great; if more than a month old practically negligible.

The bacteriological examination of a tropical water for evidence of faecal pollution attempts an answer to two questions:—(1) How much pollution? (2) How recent? When it comes to a question of the fitness of the water for human consumption neither answer can be correctly interpreted without an exact knowledge of the topography of the watershed, including such factors as its fauna and its preservation from human habitation, human trespass, or human occupation for waterworks purposes and the like.

The answer to the first question introduces the subject of the most suitable technique for the estimation of the *B. coli* and lactose fermenting bacilli in general in a water.

The American official standard for *B. coli* density in water defines *B. coli* as “including all non-spore forming bacteria which ferment lactose with gas formation and grow aerobically on standard solid media.” This is a comprehensive definition, and embraces varieties of lactose fermenters which are almost certainly not of true faecal origin.

Five biochemical tests are available for dividing the various species of lactose fermenting aerobic bacilli into two classes, those commonly met with in the faeces of warm blooded animals and those common to soil, grain, sawdust and similar substances uncontaminated with faecal matter. They are the ratio of hydrogen to carbon dioxide in the gas evolved from the fermentation of carbohydrates, the degree of acidity reached in such fermentation, the “carbinol” test, the citrate utilization test, and the time honoured indol reaction.

As far back as 1895, Theobald Smith pointed out that *B. coli* differs from such organisms as *B. lactis aerogenes* and *B. cloacae* in the amount of gas produced in glucose or lactose broth, and in the ratio of hydrogen to carbon dioxide in that gas. The method was developed by Rogers and various co-workers. The amount of hydrogen produced is fairly constant, the variation being mainly in the CO₂. In general the true faecal *B. coli* produce a very acid reaction in glucose broth and the ratio H to CO₂ is approximately unity. *B. lactis aerogenes* produces much less acid and the H-CO₂ ratio is less than unity. *B. cloacae* also produces relatively little acid and the H-CO₂ ratio is approximately 1 to 2.

For practical purposes it is easier to make use of the difference in acid production, and this is the basis of the now well known methyl red test devised by Clark and Lubs (1915). In this method of differentiating the two main groups of coli-aerogenes bacilli the composition of the medium is adjusted to the metabolic powers of the organisms in question in such a way that the reaction is left acid to methyl red in the case of the *coli* group (faecal) and alkaline in the case of the aerogenes-cloacae group (non-faecal).

The useful test devised by Vosges and Proskauer (1898) was called by them the “Kalilauge-roth reaction.” A positive result is obtained when an eosin-red colouration appears on the surface of a glucose broth tube inoculated with the organism under test, after the addition of a strong solution of caustic potash. The chemical reactions taking place are of a complex nature, a positive result depending, apparently, on the production of acetyl-methyl carbinol in the presence of the potash, hence the reaction is now commonly known as the carbinol reaction. In the routine monthly reports issued from this laboratory the term “carbinol test” has replaced the V. and P. reaction of the earlier reports.

The fourth method is of more recent introduction. It depends on the use of a synthetic medium which will support the growth of the non-faecal types of lactose fermenter but not the faecal. Synthetic media of varied composition have been tried, that now in general use was introduced by Koser. It depends on the inability of the *coli* group to utilize citrate and so produce a definite turbidity due to growth in citrate broth as do the members of the aerogenes-cloacae group.

The fifth, oldest, and best known test is the production of indol by the growth of the organism from broth containing tryptophane derivatives. This can be tested for either in the broth itself or in its volatilized products by such reagents as paradimethyl-amido-benzaldehyde and potassium persulphate. In cases of doubt the red colour produced should be extracted with amyl alcohol or other suitable solvent in order to avoid pseudo-reactions.

Using the last four tests together the results will be as follows for typical members of the two groups of lactose fermenters.

| | | Indol. | Methyl Red. | Carbinol. | Citrate. |
|--------------------------|-----|--------|-------------|-----------|----------|
| <i>B. coli</i> | ... | + | + | — | — |
| <i>Aerogenes-cloacae</i> | ... | — | — | + | + |

These tests are not absolutely reliable nor do they permit of a hard and fast line being drawn between the two types of lactose fermenters, those that normally inhabit the intestinal canal of man and animals and those that normally occur outside it; yet there can be no doubt that they are of very considerable value.

The results obtained are for the most part concordant. The gas ratio test is seldom used at the present day and for many practical waterworks purposes one or two tests will suffice, thus Houston would define "*B. coli*" as a bacillus fermenting lactose and producing indol (lagin). The vast majority of true faecal organisms conform to this definition. In routine work in this laboratory only two tests are used for lactose fermenters isolated from town water, the indol and the carbinol reaction.

Cunningham and Raghavachari (1924) working in Madras found the 97.9 per cent. of the lactose fermenters isolated from human faeces were methyl-red + carbinol — and 99.5 per cent. of those in cow dung.

The correlation between the citrate test and the others has been investigated in Burma by Taylor and his colleagues. They find that certain lactose fermenters are always citrate negative, including *B. coli communis* and *B. schafferi*, typical lactose fermenters of the human intestine, others such as *B. lactis aerogenes* and *B. cloacae*, are always citrate positive while others again such as *B. neapolitanus* are commonly citrate positive in strains isolated from water, but citrate negative as they occur in the human intestine.

The first step usually employed for the estimation of the *B. coli* density of a water is the inoculation of measured quantities of the water into a liquid culture medium containing lactose.

The particular medium employed in this laboratory is the 0.5 per cent. sodium taurocholate 1 per cent. lactose peptone water of MacConkey tinted with neutral red or the Andrade fuchsin indicator for acid formation. Each tube contains an inverted smaller one filled with the medium which serves to trap any gas produced by the fermentation of the lactose.

In the case of a water about which little is known, it is best to inoculate it into the medium in decimal series, 100 c.c., 10 c.c., 1 c.c., 0.1 c.c. 0.01 c.c., &c. For accuracy each series is repeated in triplicate. But when the quantity of lactose fermenters is approximately known it is probably better to follow American practice and inoculate a series of tubes with a suitable equal volume of water. The volume would depend on the estimated number of lactose fermenters. The greater the number of tubes inoculated the more accurate the result the method can give provided the volumes are suitably chosen.

According to the American standard, at least five equal portions of 10 c.c. each must be tested for each sample. It is laid down that not more than 10 per cent. of all the 10 c.c. portions tested shall show the presence of *B. coli* and not more than 5 per cent. of all samples tested shall show the presence of *B. coli* in three or more of the five 10 c.c. portions when twenty or more samples have been examined. The object of the latter provision is to allow for variation in quality of the water.

The underlying mathematical principles of these methods of bacteriological analysis have been developed by Greenwood and Yule (1917). Illustrative probability curves will be found in the official American Manual of Waterworks Practice.

Ten c.c. portions are only suitable for testing the Labugama lake water in the dry weather. During rains all five 10 c.c. portions would invariably be positive and in the great majority of samples all 5 one c.c. portions. In any case the results of these presumptive coli tests, as they are commonly called, are of much less significance for tropical than they are for European or North American waters. More refined methods are necessary for the study of such a tropical lake water as that at Labugama.

In 1912, Colonel Clemesha (now Malariologist to the Ceylon Planters' Association) published a most suggestive study of the Bacteriology of Surface Waters in the Tropics, with particular reference to the Madras water supplies. He pointed out that if glucose and lactose sodium taurocholate broths were inoculated with the same water by the decimal series the acid and gas formation often extended much lower in glucose than in lactose; and that the more recent the pollution the closer the agreement between the two sets of results. He attributed this interesting phenomenon to the predominance of a glucose fermenting lactose non-fermenting bacillus in stored waters called by him bacillus P. This organism was said to be rare in human faeces but common in water supplies and also very resistant to sunlight and storage.

The divergence of the acid and gas line with increasing storage and exposure of the water to sunlight holds good for Colombo. But the explanation adopted by the writer is somewhat different. The organism in the Colombo water corresponding to Clemesha's bacillus P is a late lactose fermenter producing a few bubbles of gas in lactose broth about the third day of incubation. The surface colonies on bile salt lactose agar plates are whiteish at first and then become reddish in the centre. Clemesha says that after bacillus P has been cultured for some time in the laboratory a very faint trace of acid but no gas may be seen. The Colombo organism ferments glucose, saccharose, and mannite vigorously but neither acid nor gas is produced in dulcitol, adonite or inulin, the carbinol or Voges-Proskauer reaction is very marked, no indol is formed in peptone water, gelatin is usually liquefied by the mass inoculation test of MacConkey followed by incubation for five days at 37°C and setting on ice. The bacillus is actively motile and gram negative. Bacillus P. as described by Clemesha does not ferment mannite, does not liquefy gelatin in 10 days, and is gram positive.

In the opinion of the writer the Labugama organism must be identified as a variety of *B. cloacae* Jordan (*Aerobacter cloacae* Jordan according to Bergey's Manual of Determinative Bacteriology). Jordan states that this bacillus is a variable lactose fermenter and in all other essential respects the description agrees. Despite its name, it is very doubtful indeed whether *B. cloacae* is a true faecal organism, though according to Clemesha it sometimes appears in large numbers in Indian faeces. MacConkey did not come across it once among 178 coliform organisms isolated from 20

samples of human faeces. Two strains were found in horse faeces and the remaining 12 from soil, pond water, rain water, and roof washings. It is probably only a passenger in the mammalian intestine.

It would seem, then that the results of the presumptive coli test in lactose broth are capable not only of giving the gross density of lactose fermenters of all kinds both faecal and non-faecal present in the water but also of yielding valuable information as to the degree of self-purification undergone by the water, in other words the test furnishes a partial answer to both the questions postulated above.

In order to proceed further with the bacteriological analysis it is necessary to know what kinds of lactose fermenters are present ; and in order to do this a selection of the organisms causing the change in lactose broth must be isolated, either from the MacConkey broth or from the original water. The former is the alternative generally adopted as being much the most convenient, though the method of direct isolation from plates inoculated with the original water is theoretically better. The point requires further investigation. It should be remembered that the bile salt at present on the market is less differential in its action than that available before the war. According to Clemesha no great change takes place in the relative frequency of the various types of lactose fermenters present in the water within the first 18 hours incubation in lactose bile salt broth at 37°C.

The broth, therefore, can be plated out on the corresponding lactose bile salt agar before this period of incubation has expired and a representative selection made of the discrete colonies appearing on the plates on 24–48 hours further incubation. At least ten colonies should be picked off but no attempt should be made at choosing them according to the appearance of the colony. This is far too haphazard a venture.

The best plan is to dilute a loopful of broth in a tube of sterile water or salt solution and spread out on two or more plates with a sterile glass spreader. By this means a plate showing a number of entirely discrete colonies can be obtained with regularity. All the discrete colonies should be picked off into peptone water, thus avoiding all unconscious bias in selection and ensuring a representative set of bacilli for further differential tests. If too numerous, those in a segment of the plate should be sub-cultured.

The tube inoculated with the largest quantity of water is that which will naturally be chosen for sub-culture since it is the one most likely to yield the full variety of lactose fermenters originally present in the water. A 50 c.c. tube of MacConkey double strength lactose bile salt broth was included in the original series of tests of Labugama lake waters 50 c.c. of water added to it and the types of lactose fermenters isolated from it, but 20 c.c. is the largest volume of water used in ordinary work. It should be amply sufficient for wet weather samples which show the greatest number and the greatest diversity of lactose fermenters. For dry weather samples a more representative selection of colonies could probably be isolated from 100 c.c. inoculated into 50 c.c. triple strength broth.

Assuming that the lactose fermenting bacilli thus obtained are a representative sample of those in the water itself, the choice of tests for identifying their species, or at least separating them into varieties significant from a waterworks point of view, requires to be considered.

The methods of distinguishing between the *B. coli* group and the *B. lactis aerogenes* group have been already discussed. Caution is called for in the interpretation of the results so obtained. Thus the effluent from the Colombo sewage works and certain well waters in Colombo may show quite a high proportion of the *B. lactis aerogenes* group, probably derived originally from soil washings and possibly multiplied subsequently at tropical temperature. In such a case the coli-aerogenes ratio has little significance in itself but it enables the results of the presumptive coli test to be discounted and a more accurate estimate made of the number of true faecal organisms in the fluid. Thus in the case of the sewage effluent if the total number of lactose fermenters are estimated to be 100,000 per cubic centimetre and 50 per cent. of these give the carbinol reaction the number of the faecal organisms may be put down as not more than 50,000 per c.c.

For many, if not most, hygienic purposes no further investigation is needed, but in order to gain an insight into the very significant changes in the lactose fermenting bacilli of upland surface tropical water during self-purification from faecal pollution and ascertain whether the pollution is remote or recent, it is necessary to proceed a stage further towards the complete differentiation of the various species.

The additional information required can be obtained by a study of the fermentative powers of the organisms isolated. There are two main types of fermentation tests, those in which the organism is grown in a culture medium containing an organic salt and those in which the medium contains a carbohydrate. The former method, developed by Brown, Duncan and Henry, is of recent introduction. It appears to have only one practical application to waterworks bacteriology. The salt sodium mucate is not decomposed by *B. cloacae* as it is by other members of the *aerogenes* group. The decomposition can be tested for by adding a saturated solution of lead acetate acidified with acetic acid to the culture after 48 hours growth ; if decomposition has occurred there will be no precipitate, otherwise a lead mucate will be precipitated.

Lead acetate solution can be used in a similar manner as a test for the utilization of citrate in Koser's reaction.

The best pioneer work on the subject of carbohydrate fermentation by the coli group is undoubtedly, that of MacConkey, whose papers published in the Journal of Hygiene in April, 1909, and 1905 are among the classics of public health bacteriology. His work was followed up in 1908–11 by Clemesha in Madras and Bengal and in 1911 by Archibald in Khartoum, in 1913 by the writer in Colombo, and later by many others, particularly Robinson in Malta and Taylor in Rangoon.

The Colombo results were presented to the third All-India Sanitary Conference at Lucknow, January, 1914, and are published in the proceedings of that conference. See Tables I. to V. The tests originally employed by the writer were :—Motility of a young culture in broth, indol reaction and carbinol or Vosges-Proskauer reaction after five days, liquefaction of gelatin by mass inoculation subsequent growth in the 37°C incubator for 10 days at least and then solidification of the non-liquefied cultures in ice, fermentation of lactose, saccharose, dulcite, adonite, and inulin peptone waters incubated for 5 days at 37°C. The methyl red and citrate tests were added later.

MacConkey employed a primary classification of his lactose fermenters based on the fermentation of saccharose and dulcite and allotted 32 numbers to each class. Table I. shows that out of a possible 128 combinations with the given tests only 21 were actually met with by MacConkey in his 178 colonies from 20 specimens of human fæces. The writer found 17 varieties of *B. coli* among 250 colonies from 25 fæcal specimens, mostly milk vendors under examination for a certificate of fitness for employment in a Colombo dairy. These fæces were reputed to be fresh. The strains were not replated and are not necessarily pure though picked off from entirely discrete colonies.

Amongst the Colombo strains are two species not listed by MacConkey but subsequently found by other observers. Thus lactose fermenters fermenting saccharose, dulcite and adonite and giving both the carbinol and indol reactions have been isolated by Johnstone at Liverpool, by Houston in London, and by Robinson at Malta; bacilli fermenting saccharose and adonite and giving both the carbinol and indol reactions have been isolated by Stewart and Robinson. The former bacillus is probably allied to *B. oxytocus perniciosus* and the latter to MacConkey's No. 97.

It will be noted that certain types are much more common than others in human fæces. The frequency distribution of these lactose fermenters is shown in Table II. These organisms may be regarded as true fæcal *B. coli*. Table III. shows the distribution of rarer types sometimes found in fæces but, in the opinion of the writer, probably only passengers and not permanent residents in the human intestine. It will be noted that they all belong to MacConkey's Classes III. and IV. and give a positive carbinol reaction. They may be conveniently designated pseudo-fæcal bacteria.

One of these, *B. oxytocus perniciosus*, regarded by Clemesha as an indicator of recent pollution, is very rare in human fæces. The writer believes that bacteria of this type are probably of soil origin being washed out into the water by monsoon rains upon the watershed. Four of MacConkey's eight strains of this vigorous fermenter were derived from soil. Heavy rainfall on a dry watershed exposed to fæcal contamination always leads to a great increase in the *B. coli* count and in the appearance of evidence of recent pollution of the water. According to this view *B. oxytocus perniciosus* and its congeners should be regarded as a common concomitant of fæcal pollution though not themselves of fæcal origin. Their presence, therefore, is directly indicative of flood conditions and only indirectly of recent contamination of true fæcal origin.

B. lactis aerogenes is widely distributed in nature. It is common in Colombo sewage and soil washings, but relatively scarce in human fæces. Clemesha states that no sudden prevalence of this characteristic bacillus in human fæces has ever been noted by him as is the case with certain other organisms, such as *B. cloacæ*, which are not truly fæcal. *B. lactis aerogenes* is said to appear in abundance of the Red Hills lake water, whence Madras city is supplied, some days after pollution has been added. This is a common sequence in the Labugama lake water. Clemesha believes that this organism multiplies in water under conditions associated with partial natural purification, and the evidence from the Colombo supply, so far as it goes, is consistent with this view.

Reference has already been made to the predominance of *B. cloacæ* in the well-stored water of the Labugama lake. As is the case at Red Hills in Madras it is present in greatest abundance in the deeper layers. The explanation probably is that its growth is favoured by an acid reaction of the water. All the evidence available from the study of the Colombo waterworks supports the idea that this particular bacillus is capable of multiplying in acid waters containing a moderate amount of organic matter at tropical temperatures; growth is probably most vigorous in water containing little or no dissolved oxygen. The role of this organism in tropical waters is of considerable interest and deserves more detailed investigation. It seems likely that its natural habitat is the bottom of tropical lakes and rivers.

The power of multiplication of such SCK lactose fermenting bacteria as *B. cloacæ* and *B. lactis aerogenes* outside the mammalian intestine may well turn out to be the outstanding difference in the bacteriology of tropical waters as opposed to that of temperate climes, where no evidence has so far been adduced that any lactose fermenter can multiply in water under ordinary conditions. As regards exceptional circumstances Houston's "leather" bacillus seems the most interesting so far recorded. This lactose and indol positive non-motile bacillus ferments adonite and saccharose. It was isolated from the leather washer of a tap in a pressure main in the works of the Metropolitan Water Board. It grew luxuriantly in water containing shreds of certain leathers at room temperature in London. *B. lactis aerogenes* was also found to be capable of multiplying in water containing "susceptible" leather washers. If certain lactose fermenters which are comparatively rare in fæces, can multiply in tropical waters in the absence of added fæcal pollution it is clear that no great importance can be attached to figures representing gross density of lactose fermenters in a tropical water (presumptive coli test) unless it is shown by subsequent tests that these organisms are of the true fæcal type, in which case the result has the same significance in Ceylon as in Great Britain or temperate America.

Much work has been done in India on the relative resistance to sunlight and storage of the different types of lactose fermenters met with in water. Clemesha divides these lactose fermenting bacteria into three classes on the basis of his experiments and observations in India :

- (1) The delicate organisms which are very susceptible to the action of sunlight, such as *B. coli communis*, the most typical lactose fermenter of the human intestine.
- (2) An intermediate class including the pseudo-fæcal organism *B. lactis aerogenes* and some of the true fæcal bacteria, such as *B. neapolitanus* and *B. coscoroba*.
- (3) Resistant organisms such as *B. cloacæ* and certain true fæcal bacilli of the vesiculosus-grunthal group.

The presence of Class I. microbes is regarded as a sign of recent pollution and predominance of Class III. as an assurance of safety and adequate storage.

A few similar experiments have been carried out in Colombo which lead the writer to the conclusion that a definite grading of the typical lactose fermenters according to resistance to sunlight is scarcely practicable, though it seems true that *B. coli communis* tends to disappear early, and the vesiculosus-grunthal group late. What is significant is the gradual departure from a true fæcal balance of lactose fermenters and the relative increase in certain species of the *aerogenes* group particularly *B. lactis aerogenes* and *B. cloacæ*. Sunlight is only one of the factors producing purification.

Judging from the results obtained at Labugama the stages in the natural purification of a contaminated tropical lake may be represented as follows :—

- (1) Stage of recent pollution. Predominant lactose fermenters isolated from the water include several species of true fæcal type, *B. coli communis* relatively common. Streptococci may be present. No notable extension of the acid and gas line in lactose broth after 30 hours incubation at 37°C.
- (2) Stage of early self-purification. Lactose fermenters of true fæcal type still present, usually only one or two species ; pseudo-fæcal C. K. lactose fermenters appear, e.g., *B. lactis aerogenes*.
- (3) Stage of advanced self-purification : Great predominance of the late lactose fermenting variety of *B. cloacæ* especially at depths ; Ph of water well on the acid side at deeper levels ; marked extension of the acid and gas line on prolonged incubation of lactose broth.

The complete identification of one of the Bactereæ of the fæcal genus *Escherichia* as it is called in Bergey's Manual of Determinative Bacteriology or of the non-fæcal genus *Aerobacter* must be carried on cultures carefully replated to ensure their purity. There is no royal road to the exact identification of bacterial species. Some authorities extol the value of immunological tests based on the analysis of the properties of the bacterial antigen and such tests are indeed indispensable for the proper differentiation of pathogenic organisms ; others rely chiefly on the results given by the fermentation of a large variety of carbohydrates ; others again attach supreme importance to such biochemical tests as power to utilize citrates, indol production in peptone water, or acetyl-methyl carbinol production in carbohydrate broths. No single test can be relied upon to give constant results for all bacteria under all circumstances. For instance most types of *B. coli* have an antigenic structure of great complexity, some fractions of the agglutinative antigen, for example, being common to many different strains and others highly individual. Most bacteria capable of fermenting carbohydrates at all will give rapid and constant fermentation with some carbohydrate but vary greatly in their action on others. For each bacterial group a particular series of carbohydrates may be chosen which, on the whole, will give better results than any others for the purpose of differentiation into species.

The writer has kept a large collection of bacteria in pure culture for many years and has repeatedly tested their action upon the same series of carbohydrates. Striking variations are very exceptional in the case of bacteria grown on artificial culture media, though it by no means follows that variation will not be initiated in passage through the body of an animal or in external nature, and it is well known that even such constant fermenters of carbohydrates as *B. typhosus* can be induced to mutate by appropriate means so as to act on a sugar, such as lactose, never fermented by ordinary cultures. Only the purest carbohydrates procurable should be used in fermentation tests and they must not be submitted to sterilizing processes which tend to break them down.

On the average, fermentation tests with well chosen carbohydrates would seem to be just about equal in reliability to the commonly used biochemical tests for indol production, citrate utilization, acid production in Clarke-Lubs broth, and the Vosges-Proskauer reaction.

The final judgment as to the identity of a bacterium must be based on a review of the whole evidence available from morphological, biochemical, immunological, and pathogenicity tests. The more such evidence can be made available the better, provided the issue is not confused by the introduction of irrelevant and misleading data.

The writer is of opinion that MacConkey made a very sound choice of carbohydrates for the differentiation of the lactose fermenting nonsporing gram-negative bacilli commonly found in nature. The introduction of more tests would doubtless result in an increase in the number of known varieties, some of which may turn out to be stable species having a special significance of their own in the hygiene of water supplies.

There is no point in multiplying tests with monosaccharides, such as levulose and galactose, or disaccharides such as maltose which are almost always fermented by faecal lactose fermenters. MacConkey gave a thorough trial to the following substances and rejected them for the purpose of differentiating lactose fermenters; glucose, levulose, maltose, arabinose, raffinose, quercit, erythrite, sorbite, glycerine, arbutin, salicin, amygdalin. α -methyl, glucoside, dextrin and starch. Quercit and erythrite were not affected by 100 strains tested, the others did not afford more information than is to be gained by the use of lactose, saccharose, dulcete, adonite, inulin, and inosit and may be mannite.

The writer recommends the following tests for the separation of the lactose fermenting aerobic bacilli found in tropical water supplies into significant types (not necessarily species):—

Primary.—Fermentation of saccharose, dulcete, and adonite within three days; formation of indol, methyl red reaction, carbinol reaction, Koser's citrate test, all after three days incubation at 37°C.

Secondary.—Fermentation of inulin within three days, liquefaction of gelatin after ten days at 37°C.

The formula for a complete positive reaction to every test would be SDRCKAig. The motility test is not included in the regular formula but it may be used with advantage for research work. Inulin fermenters are rare in the Colombo water supply, this test is no longer used in routine water work, nor is the gelatin liquefaction test as it takes too long to get a reliable result.

From a biometric point of view it is clearly advisable to isolate as many colonies as possible for study with due regard to the limitations imposed by time and cost.

As regards expense it should be pointed out that the use of more than 2 c.c. of fluid medium per tube is an unjustifiable extravagance. Houston has shown that gelatin is better than broth for the demonstration of slight amounts of gas formation from carbohydrates, and it may be advantageous to use a solid medium more suitable than gelatin for use in the tropics such as a soft agar. It would then be possible to dispense with the small inverted tube required to show gas formation in a liquid medium. Adonite and dulcete are expensive carbohydrates, but in the writer's opinion they yield results of such value that they cannot be dispensed with for the purpose of the final differentiation. After all, consideration of petty economy in laboratory maintenance should not be allowed undue weight when it is a question of delivering a sound verdict on the purity of water supplies constantly consumed by tens of thousands of human beings.

Raffinose and salicin have been given a trial in this laboratory; no extra information was obtained that seemed particularly useful.

Those who aim at greater simplification of technique are advised to dispense with the citrate and the methyl red tests or to retain the methyl red tube and give up the indol reaction. The latter test requires to be better standardized for the purpose of water bacteriology, since the results vary greatly with the particular peptone employed. The Clark-Lubs synthetic medium is complex; the medium including the proteose peptone of the Digestive Fermenters Co., is the one used in this laboratory. The test has the advantage that the results can be read off directly without the addition of complicated chemical solutions.

A word of warning; passage of a tropical water through sand filters and along lengthy pipe lines crusted with organic matter may completely alter the balance of the lactose fermenters originally present. Results obtained by the proposed technique from laboratory tap samples are not comparable with those furnished by samples drawn direct from the lake water itself. For the routine examination of tap or standpipe samples reliance is placed on a comparison of the colony counts, and acid and gas line discounted by ratio of lactose indol (L I) bacilli to lactose carbinol (L C) producers in different parts of the supply.

It will be evident from the foregoing and still more so from the description following of the vicissitudes in the quality of the Labugama lake water that the interpretation of the results obtained from a bacteriological sample of water depends on the precise circumstances under which the sample is taken. The writer has heard of attempts being made to judge the quality of a water supply on a single sample taken by an engineer or overseer untrained in bacteriological technique without regard to the topographical conditions of the water supply under examination. Reports on samples of this description are not worth the paper they are written on. The more delicate the method of bacteriological analysis employed the greater the care required in sampling and in recording all the data relevant to the interpretation of the result, rainfall, sunshine, depth, currents, relation to probable sources of faecal contamination and other topographical circumstances.

Every one of the samples on which the conclusions in this report are based has been taken personally by the writer. If such samples cannot be taken by the bacteriologist himself they should be taken by a specially trained collector.

The following resolution extracted from the British Medical Journal of September 12, 1912, Vol. II., p. 716, may be quoted.

“That this conjoint meeting of the sections of State Medicine and Bacteriology unanimously desires strongly to urge that no opinion as to the quality of a water be arrived at on bacteriological evidence without a local and topographical inspection of the sources of the supply made by a competent observer.”

TABLE I.—Characters of the lactose fermenting gram negative aerobic bacilli of the normal human intestine; numerical classification and species according to MacConkey's list. (Journal of Hygiene, Vol. IX., p. 94.)

| | Saccharose. | Dulcite. | MacConkey No. | Species. | Motility. | Indol. | Carbinol. | Adonite. | Inulin. | Gelatine. | MacConkey, Great Britain, 1908. 20 specimens. 178 colonies. | | Hirst, Colombo, 1914. 25 specimens. 250 colonies. | | Taylor, Burma, 1926. 8 specimens. 90 colonies. | | Robinson, 1928. Malta, Ceylon, Egypt, England, India. 2,100 colonies. | | Clemesha, Madras, 1908. 10 specimens. 171 colonies. | |
|----------------------------------|-------------|----------|---------------|--|-----------|--------|-----------|----------|---------|-----------|---|-----------|---|-----------|--|-----------|---|-----------|---|-----------|
| | | | | | | | | | | | No. | Per cent. | No. | Per cent. | No. | Per cent. | No. | Per cent. | No. | Per cent. |
| MacConkey Group I. Nos. 1-32. | — | — | 1 | <i>B. acidi lactici</i> | + | + | — | + | — | — | 9 | 5.1 | Nil. | Nil. | .. | 7.5 | 158 | 7.5 | 18 | 10.5 |
| | — | — | 2 | <i>B. levans</i> | + | — | — | — | — | — | 1 | 0.6 | 10 | 4.0 | .. | .. | .. | .. | Nil. | Nil. |
| | — | — | 3 | <i>B. Grunthali</i> | + | + | — | — | — | — | Nil. | Nil. | Nil. | Nil. | .. | 0.09 | 2 | 0.09 | Nil. | Nil. |
| | — | — | 4 | <i>B. vesiculosus</i> | + | + | — | — | — | — | 8 | 4.5 | 18 | 7.2 | .. | 34.4 | 723 | 34.4 | } | |
| | — | — | 5 | | + | + | — | — | — | — | 33 | 18.5 | 18 | 7.2 | 8 | 8.9 | 1 | 0.05 | 75 | 44.1 |
| | — | — | 6 | | + | + | — | — | — | — | Nil. | Nil. | Nil. | Nil. | .. | .. | .. | .. | } | |
| | — | — | 7 | <i>B. coli mutabilis</i> | + | — | — | — | — | — | 1 | 0.6 | Nil. | Nil. | .. | .. | .. | .. | } | |
| | — | — | 8 | | — | — | — | — | — | — | Nil. | Nil. | 4 | 1.6 | .. | 0.38 | 8 | 0.38 | } | |
| MacConkey Group II. Nos. 33-64. | — | + | 33 | | + | + | + | + | — | : | Nil. | Nil. | Nil. | Nil. | .. | 0.4 | 8 | 0.4 | Nil. | .. |
| | — | + | 34 | <i>B. coli communis</i> | + | + | — | — | — | — | 37 | 20.8 | 106 | 42.4 | 4 | 4.4 | 464 | 22.1 | 60 | 35.3 |
| | — | + | 35 | <i>B. Schaefferi</i> | + | + | — | — | — | — | 11 | 6.2 | 7 | 2.8 | 18 | 20.0 | 6 | 0.3 | Nil. | Nil. |
| | — | + | 36 | | + | — | — | — | — | + | 1 | 0.6 | Nil. | Nil. | .. | .. | 13 | 0.62 | Nil. | Nil. |
| | + | + | 65 | <i>B. oxytocus perniciosus</i> | — | + | + | + | + | + | 1 | 0.6 | Nil. | Nil. | .. | .. | 13 | 0.62 | Nil. | Nil. |
| | + | + | 66 | | — | + | + | + | — | — | Nil. | Nil. | 5 | 2.0 | .. | .. | 13 | 0.62 | Nil. | Nil. |
| | + | + | 67 | | — | + | + | + | — | — | 1 | 0.6 | 5 | 2.0 | 4 | 4.4 | 25 | 1.2 | Nil. | Nil. |
| | + | + | 68 | <i>B. Friedlander</i> | — | — | — | — | — | — | 1 | 0.6 | 2 | 0.8 | .. | .. | 9 | 0.43 | Nil. | Nil. |
| MacConkey Group III. Nos. 65-96. | + | + | 70 | | + | — | — | — | + | + | Nil. | Nil. | Nil. | Nil. | .. | .. | 1 | 0.05 | Nil. | Nil. |
| | + | + | 71 | | + | + | — | — | — | — | 42 | 23.6 | 23 | 9.2 | 14 | 15.5 | 253 | 12.4 | Nil. | Nil. |
| | + | + | 72 | <i>B. neapolitanus</i> | + | + | — | — | — | — | 15 | 8.4 | 13 | 5.2 | 17 | 18.8 | 4 | 0.2 | 4 | 2.3 |
| | + | + | 74 | | + | — | — | — | — | — | 1 | 0.6 | 3 | 1.2 | 4 | 4.4 | 2 | 0.1 | Nil. | Nil. |
| | + | + | 75 | | — | + | + | — | — | — | Nil. | Nil. | Nil. | Nil. | .. | .. | 10 | 0.5 | Nil. | Nil. |
| | + | + | 97 | | — | + | + | + | + | + | 1 | 0.6 | Nil. | Nil. | .. | .. | 1 | 0.04 | Nil. | Nil. |
| | + | + | 99 | | — | — | — | — | — | — | Nil. | Nil. | Nil. | Nil. | .. | .. | 16 | 0.76 | 3 | 2.0 |
| | + | + | 100 | | + | + | — | + | — | — | 1 | 0.6 | Nil. | Nil. | .. | .. | 53 | 2.5 | 1 | 0.5 |
| MacConkey Group IV. Nos. 97-128. | + | + | 101 | | — | + | + | + | — | — | 1 | 0.6 | Nil. | Nil. | .. | .. | Nil. | .. | Nil. | Nil. |
| | + | + | 103 | <i>B. lactis aerogenes</i> ... | — | — | — | — | — | — | 8 | 4.5 | 2 | 0.8 | .. | .. | 286 | 13.6 | 8 | 4.7 |
| | + | + | 104 | <i>B. gasiformans non-liquefaciens</i> | — | — | — | — | — | — | Nil. | Nil. | Nil. | Nil. | 2 | 2.2 | 16 | 0.76 | 2 | 1.1 |
| | + | + | 106 | | + | + | — | — | — | — | 2 | 1.1 | 10 | 4.0 | 4 | 4.4 | 3 | 0.14 | Nil. | Nil. |
| | + | + | 107 | <i>B. coscoroba</i> | — | + | — | — | — | — | 1 | 0.6 | 4 | 1.6 | 15 | 16.6 | .. | .. | 8 | 4.7 |
| | + | + | 108 | <i>B. cloacae</i> | — | + | — | — | — | — | Nil. | .. | 4 | 1.6 | .. | .. | 16 | 0.76 | 2 | 1.1 |
| | + | + | 109 | | + | — | — | — | — | + | 2 | 1.1 | Nil. | Nil. | .. | .. | 3 | 0.14 | Nil. | Nil. |
| | + | + | | | + | — | — | — | — | — | .. | .. | .. | .. | .. | .. | .. | .. | Nil. | Nil. |

B. Schaefferi and *B. gasiformans non-liquefaciens* produce only a small amount of gas. 25 colonies belonging to 8 species not shown in MacConkey's list are included among the 2,100 colonies analysed by Robinson; 20 colonies belonging to 2 species among the 250 colonies isolated by Hirst are not listed.

TABLE II.—True faecal lactose fermenting bacilli commonly present in the human intestine.

| | | | | Percentage distribution in human faeces by locality. | | | | | | | |
|---------------------|-----------------|----------|--------------------|--|----------------------|--------------------|-----------------------------|---|--|--|--|
| MacConkey Group. | Clemesha Class. | Formula. | Group Designation. | Colombo 250 colonies. | Madras 171 colonies. | Burma 90 colonies. | Great Britain 178 colonies. | Malta, Egypt, Ceylon, India, England. 2,100 colonies. | | | |
| I. 1 and 2 ... | II. ... | IRA ... | Acidi Lactici ... | 4'0 ... | 10'5 ... | Nil. ... | 5'6 ... | 7'5 ... | | | |
| I. 4 and 5 ... | III. ... | IR ... | Vesiculosus ... | 14'4 ... | 44'1 ... | 8'9 ... | 23'0 ... | 34'4 ... | | | |
| II. 34 and 35 ... | I. ... | DIR ... | Coli communis ... | 45'2 ... | 35'3 ... | 24'4 ... | 27'0 ... | 22'1 ... | | | |
| III. 71 and 72 ... | II. ... | SDIR ... | Neapolitanus ... | 14'4 ... | 2'3 ... | 34'4 ... | 32'0 ... | 12'5 ... | | | |
| IV. 106 and 107 ... | II. ... | SIR ... | Coscoroba ... | 4'0 ... | 4'7 ... | 21'1 ... | 1'7 ... | 13'6 ... | | | |

TABLE III.—Lactose fermenting aerobic bacilli found in human faeces, but with a probable normal habitat outside the intestine of warm blooded animals.

| | | | | Percentage distribution in human faeces by locality. | | | | | | | |
|------------------|-----------------|--------------|--------------------------|--|----------------------|--------------------|-----------------------------|--|--|--|--|
| MacConkey Group. | Clemesha Group. | Formula. | Group Designation. | Colombo 250 colonies. | Madras 171 colonies. | Burma 90 colonies. | Great Britain 178 colonies. | Malta, Ceylon, India, England. 2,100 colonies. | | | |
| III. 65 ... | I. ... | SDICKAig ... | Oxytocus perniciosus ... | Nil. ... | Nil. ... | Nil. ... | 0'6 ... | 0'6 ... | | | |
| IV. 103 ... | II. ... | SCKA ... | Lactis aerogenes ... | 0'8 ... | 0'5 ... | Nil. ... | 4'5 ... | 2'5 ... | | | |
| IV. 108 ... | III. ... | SCKg ... | Cloacae ... | 1'6 ... | 1'1 ... | Nil. ... | Nil. ... | 0'8 ... | | | |

MacConkey Group III. No. 67, S D C KA, Group IV. No. 97, S I R CAig, and Group IV. No. 104, S KA may also belong to this class of “passengers” in the human intestine.

Formula :—A positive reaction is indicated alphabetically thus—

- I = Indol formed within three days in tryptophane peptone water. Paradimethylamido-benzaldethyde test.
- R = Red colouration in Clark-Lubs methyl red glucose proteose peptone water.
- C = Red colouration within three days in glucose broth after addition of strong caustic potash solution.
- K = Definite turbidity in Koser’s citrate broth in three days.
- S = Saccharose peptone water fermented with acid and gas production in three days.
- D = Dulcite peptone water fermented with acid and gas production in three days.
- A = Adonite peptone water fermented with acid and gas production in three days.
- i = Inulin peptone water fermented with acid and gas production in three days.
- g = Gelatin liquefied in ten days after massive inoculation and culture at 37°C.

The 2,100 lactose fermenting types analysed by Robinson, include 20 from Egypt (Archibald), 354 from Ceylon (250 reported by Hirst and 104 by Castellani), 88 from London (Houston), 178 from Great Britain (MacConkey), 104 reported by Medical Research Committee’s Report No. 5, and 150 from Malta (Robinson).

TABLE IV.—Typical results of Bacteriological Examination of Labugama Lake Water.

| | | | Dry Sunny Weather September 1913. | | | Wet Cloudy Weather May 1913. | | | |
|--------------|-----|-----|--------------------------------------|-----|-------------------------------|---------------------------------|----------------|-----|-------------------------------|
| | | | Colonies per cc. 48 hours at 37°C. | | | | | | |
| | | | Plain agar. | | Lactose Bile Salt agar. | | Plain agar. | | Lactose Bile Salt agar. |
| 1 foot deep | ... | ... | 28 | ... | 3 | ... | 36 | ... | 6 |
| 24 feet deep | ... | ... | 14 | ... | Nil. | ... | 348 | ... | 107 |
| 60 feet deep | ... | ... | 16 | ... | 2 | ... | 214 | ... | 32 |

Presumptive Coli Test.

MacConkey lactose bile salt broth.

+ + = acid and gas in 30 hours.

+ = acid and gas in 72 hours.

| One foot dry weather sample. | | | | | | | | | | One foot wet weather sample. | | | | | | |
|------------------------------|-----|-----|---|-----|-----|-----|-----|-----|-----|------------------------------|-----|-----|-----|-----|-----|---|
| Tube | | | | | | | | | | Tube | | | | | | |
| 123 | | | | | | | | | | 123 | | | | | | |
| 50 c.c. | ... | ... | + | + | ... | .. | ... | .. | ... | + | + | ... | .. | .. | .. | |
| 10 c.c. | ... | ... | + | + | ... | + | + | ... | .. | ... | + | + | ... | . | . | |
| 5 c.c. | ... | ... | + | + | ... | + | + | ... | + | + | ... | + | + | ... | + | + |
| 1 c.c. | ... | ... | + | + | ... | + | ... | + | ... | + | + | ... | + | + | ... | + |
| 0.1 c.c. | ... | ... | + | ... | — | ... | — | ... | ... | — | ... | — | ... | — | ... | — |
| 0.01 c.c. | ... | ... | — | ... | — | ... | — | ... | ... | — | ... | — | ... | — | ... | — |
| 0.001 c.c. | ... | ... | — | ... | — | ... | — | ... | ... | — | ... | — | ... | — | ... | — |

| 24 feet dry weather sample. | | | | | | | | | | 24 feet wet weather sample. | | | | | | | |
|-----------------------------|-----|-----|---|-----|-----|-----|-----|-----|-----|-----------------------------|-----|-----|-----|-----|-----|----|---|
| Tube | | | | | | | | | | Tube | | | | | | | |
| 123 | | | | | | | | | | 123 | | | | | | | |
| 50 c.c. | ... | ... | + | + | ... | . | ... | .. | ... | + | + | ... | .. | ... | .. | .. | |
| 10 c.c. | ... | ... | + | + | ... | + | + | ... | .. | ... | + | + | ... | .. | .. | .. | |
| 5 c.c. | ... | ... | + | + | ... | + | + | ... | + | + | ... | + | + | ... | + | + | |
| 1 c.c. | ... | ... | + | ... | — | ... | — | ... | ... | + | + | ... | + | + | ... | + | + |
| 0.1 c.c. | ... | ... | — | ... | — | ... | — | ... | ... | + | + | ... | + | + | ... | + | + |
| 0.01 c.c. | ... | ... | — | ... | — | ... | — | ... | ... | + | + | ... | + | + | ... | + | + |
| 0.001 c.c. | ... | ... | — | ... | — | ... | — | ... | ... | — | ... | — | ... | — | ... | — | — |

| 60 feet dry weather sample. | | | | | | | | | | 60 feet wet weather sample. | | | | | | | |
|-----------------------------|-----|-----|---|-----|-----|-----|-----|-----|-----|-----------------------------|-----|-----|-----|-----|-----|----|---|
| Tube | | | | | | | | | | Tube | | | | | | | |
| 123 | | | | | | | | | | 123 | | | | | | | |
| 50 c.c. | ... | ... | + | + | ... | .. | ... | .. | ... | + | + | ... | .. | ... | .. | .. | |
| 10 c.c. | ... | ... | + | + | ... | + | + | ... | .. | ... | + | + | ... | .. | .. | .. | |
| 5 c.c. | ... | ... | + | + | ... | + | + | ... | + | ... | + | + | ... | + | + | + | |
| 1 c.c. | ... | ... | — | ... | — | ... | — | ... | ... | + | + | ... | + | + | ... | + | + |
| 0.1 c.c. | ... | ... | — | ... | — | ... | — | ... | ... | + | + | ... | + | + | ... | + | + |
| 0.01 c.c. | ... | ... | — | ... | — | ... | — | ... | ... | + | + | ... | — | ... | — | — | — |
| 0.001 c.c. | ... | ... | — | ... | — | ... | — | ... | ... | — | ... | — | ... | — | ... | — | — |

TABLE V.—Biochemical characters of lactose fermenting gram negative bacilli isolated from
50 c.c. tubes of double strength bile salt lactose broth inoculated with
50 c.c. of sample and incubated 18 hours at 37°C.

Dry Weather Series, September, 1913.

[illegible]

Wet Weather Series, May, 1913.

[illegible]

TABLE VI.—Labugama Lake Waters, 1928.

| | | | | March 19, 1928. Moderately wet weather. | | | November 14, 1928. Wet weather. | | |
|---------------------------------------|-----|-----|-----|--|-----|---------------------|------------------------------------|----------------------------------|--|
| | | | | (1) 2 foot sample | | (2, 20 foot sample. | | (3) 8 foot sample. (Drawoff.) | |
| | | | | Colonies per c c. 48 hours at 37°C. | | | | | |
| Plain agar | ... | ... | ... | 108 | ... | 52 | ... | 142 | |
| Lactose bile agar... | | ... | ... | 19 | ... | 6 | ... | 43 | |
| Presumptive coli test acid and gas in | | ... | ... | 0.1 c.c. | ... | 1 c.c. | ... | 0.1 c.c. | |

Biochemical characters of lactose fermenters isolated from 25 c.c.
lactose bile salt broth after 18 hours incubation.

| (1) 2 foot sample 10 colonies. | (2) 20 foot sample, 10 colonies. | (3) 8 foot sample. 23 colonies. |
|-----------------------------------|---------------------------------------|------------------------------------|
| <i>B. neapolitanus</i> SDIR ... 5 | SDCKA ... 8 | <i>B. neapolitanus</i> SDIR ... 6 |
| <i>B. coli communis</i> DIR ... 2 | SDC ... 1 | <i>B. coli communis</i> DIR ... 5 |
| SDCKA ... 2 | <i>B. lactis aerogenes</i> SCKA ... 1 | <i>B. coscoroba</i> SIR ... 3 |
| SDK ... 1 | | SDRK ... 3 |
| | | SR ... 2 |
| | | <i>B. friedlander</i> SDKA ... 2 |
| | | SDCK ... 1 |
| | | SDC ... 1 |

For results of dry weather samples taken on September 10, 1928, see section on mechanical filtration plant.

On Certain Hygienic and Economic Problems.

Each stage in the journey of every drop of the Colombo water from the watershed, through the Labugama lake, the treatment works, the main pipe lines, the service reservoirs and the distribution system to the consumer has its own special problems. Each problem will be considered under the appropriate heading, before attempting to summarize the methods recommended for its solution and for the general betterment of the water supply.

Reference has already been made to the writer's observations on the bacteriology of the town supply begun in 1912 as soon as possible after the laboratory was opened. By 1915 the nature of the organic incrustation of the pipes had been discovered, thanks largely to the co-operation of eminent experts in Europe.

The work was interrupted for more than five years by the writer's absence on active service at the Great War and the long illness consequent upon it.

During 1920-21 a laboratory method was discovered for the treatment of the water which enabled the growth of the organic incrustation to be prevented or greatly retarded. During this period the first series of experiments on chlorination were carried out and also the first series of tests on the bacteriological efficiency of the filters.

The extensive alterations to the Waterworks, the raising of the dam and the time taken up by the elaborate series of researches on plague and hookworm diseases published from this laboratory occasioned many interruptions to the systematic observations and experiments now reviewed comprehensively for the first time, but reported at intervals in piecemeal fashion in successive annual reports, particularly those dated 1920, 1921, and 1922.

The Watershed.

A visitor stationed on the straining shaft at Labugama on looking down the lake sees before him a long reach of water extending to a distant island and on his right and left a continuous expanse of jungle extending from the surrounding hill tops down to the clearing at the waterside. The struggle for existence must be at its fiercest in that huge mass of vegetation, so closely set that its penetration is a matter of great difficulty.

The prospect pleases and, owing to the natural obstacles, man is nowhere to be seen, yet to the microbiological eye it is not altogether without vileness. On close observation the tops of the green and auburn branches may be seen to shake here and there with a motion other than that due to wind. This movement is due to the leaps from tree to tree of one or other of the two species of the primates inhabiting the catchment area, *Macacus sinicus (pileatus)* the Ceylon toque monkey, commonly known as the red monkey, and *Pithecius senex nestor vel velutus nestor* the low-country wanderoo or gray monkey ; the first is a macaque and the second a langur.

The writer has personally seen many troupes of both species amongst the tree-tops of all parts of the watershed. The total monkey population must be considerable. The langur, which seems to predominate, is almost exclusively arboreal, it moves swiftly and gracefully from branch to branch. This species is probably exclusively herbivorous. The omnivorous macaque on the other hand not infrequently descends to earth.

The monkey troops wander from place to place in search of new green leaf. Certain localities seem to have a particular attraction for them, for example the jungle in the vicinity of the Waterworks Bungalow and that opposite to the Filter House. Curiosity about their human cousins may be the magnet.

A certain amount of the excrement of these monkeys must reach the lake water when the steep declivities of the catchment area are washed by the monsoon torrents. But it is probable that freshly deposited material is only swept into the feeder streams or down directly into the lake when the rainfall is heavy.

Clearly such casual pollution of the water, though objectionable on aesthetic grounds, is not necessarily significant from a hygienic point of view if the diseases of the lower animals inhabiting the watershed, including the lower primates, are not communicable to highest of this order *Homo sapiens*, perhaps more appropriately named *Homo faber*. Some 300,000 of this species, to which both writer and reader belong, inhabit the City of Colombo and are the chief consumers of the drainage of the Labugama watershed. Since the supply was first delivered belief in its essential purity has been based on this assumption that the fauna inhabiting the catchment area are in fact free from pathogenic organisms capable of causing water-borne disease in man.

There is no reason to suspect that the bacterial diseases from which man suffers are common to the lower primates in a state of nature, though pathological studies at the Zoological Gardens show that the case is different there and that diseases, such as tuberculosis and bacillary dysentery, are common among monkeys in captivity.

As regards other communicable diseases there is reason to suspect that yellow fever may occur in wild monkeys. In South America epidemics of a disease that may be yellow fever have often preceded epidemics of true yellow fever in man. Certainly it is possible to communicate yellow fever to monkeys experimentally and apparently also measles.

None of the characteristic worms found in human beings in Ceylon have so far been found to occur in monkeys.

A grave suspicion, however, has quite recently arisen concerning the possible inter-communicability of certain pathogenic protozoa between monkeys and man. It has long been known that the anthropoid apes and the lower primates harbour amoebae closely similar, morphologically, to those met with in the human intestine, viz., *Entamoeba histolytica*, *E. coli*, *Endolimax nana*, *Iodamoeba butschlii*, and *Dientamoeba fragilis*, but it was generally believed that they were not really identical and certainly there was no proof of such identity. But in December, 1928, a paper by Clifford Dobell, F.R.S., appeared in Parasitology reporting the first results of a comprehensive series of researches on the intestinal protozoa of monkey and man. This well-known observer has applied not only morphological but also cultivation and experimental tests to the protozoa of his macaque monkeys. He has definitely identified *E. histolytica*, *E. coli* and *Endolimax nana* in *Macacus sinicus*, *Macacus rhesus* and *Macacus nemestrinus*. He states that his *M. sinicus* is derived from Southern India, but his note on its geographical distribution together with information kindly given me by W. W. A. Phillips, our local mammal expert, makes it clear that Dobell's principal observations were made on the bonnet monkey, *Macacus radiatus*, and not on its close Ceylon ally, *Macacus sinicus*. I agree with Phillips that what applies to the one will without doubt be found to apply to the other.

Only one of the three amoebae common to man and the macaques is definitely pathogenic to man, the other two are harmless commensals. *Entamoeba histolytica* is the organism producing amoebic dysentery, abscess of the liver and other forms of amoebiasis both in man and monkey.

Dobell claims to have worked out the complete life cycle of development of *E. histolytica* in *Macacus radiatus*. He divides it into four successive stages; (1) trophic, (2) precystic, (3) cystic (4) metacystic back to trophic and so on *ad infinitum* or at all events *ad libitum*. For details reference should be made to the original paper. The trophic form is that which produces dysenteric lesions and destruction of the liver tissues.

The particular strain studied in such detail by Dobell was originally isolated in 1926 from an adult male *Macacus radiatus* (*sinicus*) which was found to be a healthy carrier of two strains of *E. histolytica* (one with small cysts and one with large) and *Endolimax nana*. These cysts were cultured by Dobell and Laidlaw's modification of the Boeck-Drhoblav technique. When the newly hatched amoebae were fed to kittens they produce typical acute amoebic dysentery. Dobell is convinced that the amoeba isolated from this South Indian monkey is specifically identical with the similar form which produces so much sickness and mortality in man in the tropics. The complete evidence, however, is not yet published and Dobell's work has not yet been confirmed by other observers, though personally the writer has little doubt that it will be.

Dobell has succeeded in transmitting *E. histolytica* from man to macaque and he also reports that *E. histolytica* infections in macaques are curable by emetine just as are those of human beings. There is no definite evidence as yet that the simian strain of *E. histolytica* is pathogenic to man. Dobell is attempting to procure evidence on this important point. He states in a letter to the writer that the reaction of man to infection with simian strains of *E. histolytica* is still quite unknown and that this parasite does not usually produce dysentery or liver abscess in monkeys but lives in them as a harmless commensal.

Castellani in 1908 observed an amoebic liver abscess in *M. sinicus* in Ceylon but he considered the amoeba to be a new species and gave it the name *Entamoeba nuttali*. Dobell writes as follows regarding such prior observations: "To my mind no absolutely certain zoological conclusions can be drawn from any observations yet published on any species of intestinal protozoa found in any species of monkey." It is noteworthy, however, that Musgrave and Clegg (1904) stated that they had occasionally observed natural amoebic infections in Philippine monkeys and that McCarrison (1919) stated that monkeys employed by him in most of his experiments were very liable to attacks of amoebic dysentery.

The hygienic significance of simian *E. histolytica* is still *sub judice*, but it should not be necessary to emphasize the great importance of the issues involved to the health of tropical communities depending for their water supply upon uncleared watersheds. The subject is under investigation at Labugama. No conclusive evidence tending to incriminate the monkeys has yet been obtained at the moment of writing. It is however the writer's duty to point out that until the question whether the macaques and langurs found in the Labugama watershed are natural carriers of infective *E. histolytica* or not is solved, the water supply of Colombo is suspect as a possible source of amoebiasis. Since the macaque is a mixed feeder and the langur subsists on a purely vegetable diet the former species is much the more likely to be infected.

In the meantime there is no cause for alarm. Amœbic cysts are large objects in a microscopic sense, easily arrested by mechanical filters even when worked at a very high rate of filtration. Moreover, human amœbic carriers are exceedingly common in all tropical communities, probably at least 10 per cent. of the indigenous population of Colombo City harbour the cysts of *E. histolytica*. Hence the chance of direct contact infection must be very much greater than the hypothetical risk attached to the consumption of the City water supply. For reasons which will presently appear it is only during periods of heavy rainfall on the watershed that the rate of addition of amœbic cysts to the water will more than counterbalance their rate of disappearance due to the natural forces of self-purification.

Clearly the closer a polluted stream is to the draw-off the greater the risk of amœbic cysts entering the Waterworks. Few cysts gaining access to the water at the far end of the lake would be likely to reach the outlet end; unlike *B. typhosus* they are not motile and would tend to sediment out of the water much more rapidly than ordinary bacteria. It should be borne in mind, however, that American experience demonstrates that high winds may speed surface pollution across very large lakes.

Hitherto the filters were supposed to serve primarily economic purposes, the arrest of as many pipe-crust-forming organisms as possible and the elimination of as much suspended matter as possible at reasonable cost, but now it would seem likely that a hygienic object must be superadded and it becomes desirable to aim at a higher level of filtering efficiency.

No precise data are available regarding the viability of amœbic cysts in water at tropical temperatures. Dobell states that his monkey strain of *E. histolytica* cysts can live in a culture medium in distilled or tap water or in Ringer's fluid for two or three weeks, and exceptionally for four or five at ordinary room temperature at Hampstead, but that at 37°C. (blood heat) they can survive in water for only a few days at most. On the other hand, the viability of the amœba itself is promoted by temperatures approaching blood heat. Amœbic cysts require very large doses of chlorine to kill them, so large that chlorination alone as ordinarily practised will not suffice to safeguard the water from amoebic infection.

Since it would seem that storage and temperature are the main safeguard against amœbic infection it is important to consider exactly what amount of storage the water habitually undergoes before delivery. The average effective storage in the lake can only be a fraction of the theoretical. Winds and currents tend to interfere with the great dilution of the contaminating matter which would otherwise take place in a reservoir holding nearly 2,000 million gallons of water at spill level.

Judging from experiments with fluorescein water may pass through the settling tank in twenty minutes. It takes about ten minutes for water to pass from the draw-off in the straining shaft to the inlet of the settling basin. Another two hours may be allowed for the water to reach the main pipe line from the settling basin after passing through the filters and the clear water tank. It takes about seven hours for the water to travel along the main pipe line and sixteen hours to pass through the service reservoirs: say about twenty-six hours storage in all at a mean temperature of 80°F. It would appear highly probable, therefore, that under present conditions some amœbic cysts could be ingested by consumers in a viable state if they reached the draw-off the same day that they were excreted by man or monkey.

No exact survey of the Labugama fauna has yet been made. In the days before the development of roads and rubber plantations in the district the neighbourhood of the watershed was a hunting ground for big game—leopard, elephant, and deer. An elephant kraal was once held near the reservoir site. Leopard and deer have been observed up to quite recent times and pig is present. As regards protozoan infection among animals other than monkeys it may be noted that according to Wenyon (Protozoology) spontaneous amœbic dysentery in dogs has been described by several observers in Africa, Asia, and America. Dogs can be infected with *Entamœba histolytica*. Franchini (1920–23) has recorded natural amœbic dysentery in an Italian cat. Some observers believe that rats may act as carriers of *E. histolytica*, and if so it is possible that some of the rodents inhabiting the Labugama watershed are also carriers. Pigs may harbour an *Entamœba* closely resembling *E. histolytica*.

Epidemiologically, human sources of pollution of a watershed are much more important than those attributable to any species of animal, however closely akin to man it may be.

Fortunately, the impenetrability of the jungle and the leeches that abound everywhere discourage trespass at almost all parts along the circumference of the catchment area. When the writer first explored the head waters he found it a matter of difficulty to proceed along the right branch of the main stream even with the assistance of a gang of coolies armed with machetes.

Now there is a path along this stream leading from the lake through the jungle to the open patna beyond. Plantations are creeping up to the confines of the catchment area. The stream in question arises from a swamp in an open area of patna land and a right of way exists across its head. Though the boundaries of the catchment area are well patrolled and a barbed wire fence now protects the head waters, it would seem that the situation is not so secure as it was in former days, though the Colombo water supply still compares favourably in respect of preservation from human trespass with any other in the East.

Still more important than the somewhat remote possibility of occasional pollution by trespassers is the corresponding risk from the labour force employed in jungle clearing and similar work on the catchment area.

Enteric and dysentery are extremely prevalent in Ceylon. A large proportion of the population are carriers of either amœbic or one or other of the dysentery bacilli, among which *B. dysenteriae* Flexner greatly predominates. As regards enteric it has been estimated that the percentage of typhoid convalescents who are temporary carriers of *B. typhosus* amounts to about 17 per cent. of the total cases and something like 4 per cent. of these cases continue to excrete *B. typhosus* more or less constantly for the remainder of their lives. The number of bacilli excretable by a single carrier may be enormous. Sir Alexander Houston found 9,900,000 typhoid bacilli per cubic centimetre in the first urinary typhoid case he had the opportunity of examining. The average

normal excretion of urine may be put at about 1,200 cubic centimetres per day, so that even supposing perfect admixture took place between the total urine passed by such carrier and the water of the Labugama lake there would be between 5 and 6 *B. typhosus* per gallon. Should such a pollution be speedily carried to the draw-off in the surface layers of the water a dangerous dose of *B. typhosus* might possibly reach the consumer even if the filters were working with the maximum bacteriological efficiency ever obtained to date.

B. typhosus begins to die out as soon as it passes from the human body at a rate which varies enormously according to the factors operating, of which time, temperature, reaction (Ph) of the water, and accessibility to sunlight are probably the most important. The most instructive observations are those published by Sir Alexander Houston on the survival of *uncultivated* urinary *B. typhosus* in Thames river water in his 6th and 7th Research Reports to the Metropolitan Water Board. Uncultivated strains have a much shorter life outside the human body than those which have been grown on artificial culture media. As regards temperature the great influence it exerts is well exhibited by the results shown in the 7th Research Report. Thus in one experiment an average initial number of 103,328 cultivated *B. typhosus* was added to a series of raw water samples kept at different temperatures; the 0°C experiment showed 47,766 surviving bacilli after one week, 980 after two weeks, 34 after four weeks, one after eight weeks, and nil after nine weeks; at 18°C, a common room temperature in Europe, there were 39 at the end of one week, three at two weeks, and none by the fourth week; at 27°C, a common temperature for the Colombo supply, there were 19 after the first week, an average of 0.1 at the end of the second week, and nil at three weeks. As Houston says it is strikingly obvious that temperature is an important factor, and the lower the temperature within the limits 0°–37°C the longer does this bacillus show evidence of its existence or survival. The same experiment serves to illustrate the effect of storage. The bactericidal action of the sun's rays only operates on the surface layers of the water to a depth varying inversely with its turbidity.

Contrary to popular belief disease germs such as *B. typhosus* live longer in pure water than in water containing numerous rival organisms. Infusoria feed on *B. typhosus* and may lead to its disappearance in a remarkably short time.

In the light of growing epidemiological knowledge and experience, the modern tendency is to emphasize the importance of intermittent accidental or casual pollution by disease carriers as against more constant but less significant sources of faecal pollution of water supplies. The risk of the sewage of a community giving rise to water-borne disease probably depends more on the proportion of disease carriers present in it than on any other factor. The larger the community the more likely it is that typhoid and dysentery carriers will form part of it. To quote Houston, "Owing to the discovery of typhoid carriers the question of accident has assumed a new and even deadly significance. We know now that a relatively gross pollution, derived from the sewage of a large community *may be* less dangerous than traces of contamination coming from a single individual of unknown health history. If the danger unit is a "carrier" (and some hold that three to four out of every 1,000 persons of the population are in this condition), his or her discharges may be 10,000 times more infectious than crude sewage volume for volume."

In Ceylon the ratio between infected and uninfected casual pollutions of water supplies, either at source or subsequently through flaws in the distribution system, must be far greater than in most parts of Europe or America owing to the greater average incidence of intestinal infections.

Given inadequate supervision of the labour force employed upon a catchment area in the tropics it is only a question of time before the water supply will actually become infected with the germs of a water-borne disease.

During the first six months of 1925 when extensive jungle clearing operations were in progress the writer examined 130 waterworks employees for evidence of typhoid and bacillary carriage. The initial test employed was the agglutination of the various types of organisms by the suspect's blood serum. As is always the case with tropical communities, a fairly high percentage of agglutinators was found (11.5 per cent. *B. typhosus* in a dilution of 1/30 of the serum) but no organism of the enteric or dysentery groups could be recovered from specimens of faeces alleged to be derived from these agglutinators. Some delay is inevitable in securing batches of such faecal specimens and despatching them to Colombo. Evidence of this type is merely presumptive and by no means conclusive of freedom from infection. In order to definitely exculpate a group of workers of all suspicion of being enteric or dysentery carriers it would be necessary to isolate each one of them in hospital and examine a series of properly collected fresh faecal specimens. For the purpose of the search for protozoa it is especially important that the material examined should be absolutely fresh: the cysts of *E. histolytica* become unrecognizable at tropical temperature within a few hours of their excretion from the body.

The writer cannot, however, for obvious reasons, accept responsibility for the certain detection of disease among groups of coolies resident outside his station.

Though the writer is not responsible for the conservation of the watershed, he has explained the situation to the Waterworks Superintendent, but it is scarcely fair to this official to expect him to exercise close and constant supervision of the behavior of ignorant coolies working in a situation where they can easily escape observation.

The chlorination of the supply with a dose adequate to insure absence of *B. coli* from at least 90 per cent of all 100 c.c. wet weather samples is recommended as a second line of defence against casual pollution with the bacteria of water-borne disease. Rapid advances have been made of the technique of chlorination of recent years. Apparatus which is practically automatic in its operation is on the market and liquid chlorine is now manufactured in India. The water supplies of such well known cities as London, Bombay, Calcutta, Madras, and Rangoon are all chlorinated in whole or in part greatly to the advantage of the consumers. The risks of serious pollution to which the Labugama lake supply is exposed are very small in comparison to some these sources but it is the writer's opinion that they are no longer negligible. In the case of London there are three lines of defence against water-borne disease: storage in huge artificial reservoirs

for a period long enough to ensure the death of all, or nearly all, the enteric germs which may perchance pass into the works, slow sand or rapid mechanical filtration, followed, since 1916 by chlorination. In the case of the Labugama supply storage is very unequal in its effects and the filters, though they must greatly diminish the number of disease producing organisms, cannot eliminate them altogether even when working under ideal conditions ; after filtration the organism will still be present but in a larger volume of water.

A bacillary infection of the enteric type differs from a protozoal, such as that due to *Entamoeba histolytica*, in one important respect. If even a few stray living *B. typhosus* arrive at Colombo and gain access to a nutrient medium, such as milk, they may start to multiply and the consumption of the milk may originate an outbreak of enteric fever. The amœbæ also may excyst and pass through their various stages of development outside the body but only in very special sorts of culture media under specially favourable conditions unlikely to be met with in practice, for instance the medium must be kept at or near blood heat. In practice, therefore, the occasional access of a few *E. histolytica* cysts to a water supply is less dangerous than a corresponding degree of infection with *B. typhosus*. Moreover, the one infection can be controlled by the appropriate treatment with such drugs as emetine hydrochloride, stovarsol, and yatren, and when so treated the mortality from amœbiasis is negligible, whereas the clinical course of enteric cannot be modified with any degree of certainty by any therapeutic measures at present known. The mortality of enteric due to *B. typhosus*, if unmodified by anti-enteric inoculation, may be as high as 30 per cent.

The dose of chlorine required would depend on the state of the water. Suspended matter absorbs chlorine. No disinfectant action is obtained till the affinity for chlorine of the organic matter in solution or in suspension has been satisfied. Hence it would be more economical to apply the chlorine to the filtered water. It should be thoroughly mixed with the water in the clear water basin. There is ample time for the chlorine to exert its full disinfection action before reaching the consumer. The dose required would probably vary from about 0.2 to 0.5 parts per million and the cost would be about Rs. 40 per diem at the present price of chlorine. The cost of an installation capable of delivering 80 lb. of liquid chlorine per diem *i.e.*, more than twice what would usually be necessary, would be under Rs. 24,000.

As regards taste troubles a great deal more is now known about the subject than in the early days of chlorination. Reference may be made to the reports of Sir Alexander Houston issued by the Metropolitan Water Board for details of the superchlorination, permanganate and ammonia methods which have been successfully employed in London and elsewhere. See also the paper read by Howard and Thompson at the 45th Annual Convention of the New England Waterworks Association which is summarized in Sir Alexander Houston's 21st Annual Report and the abstract of the article by Adams on the iodoform taste acquired by chlorinated water in the 19th Annual Report. Adams showed that such tastes are due to be absorption of minute traces of pheneloid bodies from the atmosphere and their interaction with chlorine.

The Labugama Reservoir Water and its Treatment.

On a clear sunny day in the dry weather an observer in a boat in the bay at the far end of the lake looking down into the water discharged by the main stream will see a deposit of black silt at the bottom and on its surface twigs and leaves in every stage of disintegration into mould. The remains of millions of leaves lie there. Bubbles of marsh gas (methane) continually arise and break upon the surface. A similar process must be taking place on a smaller scale at the mouth of many streams entering the reservoir.

The Waterworks Engineer proposes to place hakes or silt traps at the mouth of each large stream and, if possible, to dredge the long standing deposit of organic matter at the mouth of the main stream. This should bring about a definite decrease in the organic matter in solution in the water as a whole and in the number of microbes it is able to support.

Silt also accumulates at the deep end of the lake opposite the straining shaft, but large quantities of this can readily be scooped out, whenever surplus water is available, by opening the bottom sluice.

Let the variations in the quality of the water passing into the supply be now considered. In the first instance suppose the weather has been dry for the preceding month and the level of the water about three feet above the thirteen foot sluice. Under these conditions the water passing into consumption will be of the highest quality. Lactose fermenters of the true faecal type will probably be absent from 100 c.c. The count on ordinary agar may be less than one per cubic centimeter. Chemically the water will be exceptionally pure and well oxygenated and physically it will be clear, odourless, and tasteless. In fact the ideal water that has given the Colombo supply its great reputation.

Now let the sky darken and a cyclone appear on the scene. Torrential rains descend upon the watershed, raising the water level by many feet within twelve hours, and sweeping immense quantities of organic debris into the lake. A great change in the water soon takes place; it becomes turbid and develops a slight taste of iron, the albuminoid ammonia figure goes up, ammonia and even nitrites may appear, the bacterial count rapidly rises and true faecal lactose fermenters appear in volumes as small as 1/10 of a c.c. or even less. In short the water becomes bad as judged by any arbitrary official standard.

Now let the rain cease and the sun once more appear. The complex bio-chemical and physical processes known as self-purification at once begin. The suspended matter sinks. As transparency increases at the surface levels the rays of the sun, the most potent force in nature, commence to exert their tremendous disinfecting and photo-synthetic power. Algae, protozoa, and numerous bacteria attack the organic matter brought in by the storm and break it down towards the inorganic state, taking up much dissolved oxygen in the process, which is continuously renewed from the surface of the water. Before very long the water is restored to all appearances to its original purity.

Let a period of prolonged drought now supervene. The lake level sinks but the surface layers of the water retain much of their purity. The count of late lactose fermenters such as *B. cloacae* rises at levels more than a few feet beneath the surface. At greater depths iron and acidity increase and dissolved oxygen diminishes. Bacteriologically, *B. cloacae* is the only non-sporing aerobe found among the bacilli isolated from lactose bile salt broth. The tint of the water deepens and it tastes of iron, if anaerobic conditions are reached at the bottom, gases such as sulphuretted hydrogen enter into solution to be oxidised however as soon as a layer containing dissolved oxygen is reached. If the water from the bottom is drawn off by a vacuum apparatus and exposed to air it deepens considerably in colour and soon deposits a heavy precipitate of ferric hydrate. Suppose now the drought comes to an end abruptly by the burst of a monsoon and enormous quantities of water descend continuously upon the watershed, the whole body of the lake water is churned up and not only the organic matter already mentioned added together with its associated bacteria but quantities of mineralized detritus from the laterite soil on the exposed sides of the reservoir. These are the conditions which give rise to complaints of taste and odour in the water supplied to the consumers.

The treatment required to insure the delivery to the consumer of a water of the highest possible quality under all conditions, bad, good, or indifferent, may now be considered.

In the opinion of the writer the water at its best requires no treatment except chlorination with a minimum dose of chlorine as a safeguard against the forms of casual pollution of human origin already mentioned. At present the water withdrawn from near the level of the topmost sluice is passed through the filters, but probably no advantage accrues under dry weather conditions if the level is within 3 feet of the draw-off. In fact the effect of passing such water through the treatment works is actually to add to the general bacterial count and especially to the number of *B. cloacae* present. But if the water is at spill level, *i.e.*, 13 feet above the sluice, a marked improvement in its chemical and bacteriological quality can be effected by adding a small dose of coagulant to the water as it enters the present settling basin. Under average conditions up to half a gram of alumino-ferric neutralized with sodium aluminate, sodium carbonate or lime may be employed without increasing the resistance of the filters to the point of necessitating too frequent use of the machinery for washing. Details of the experiments on which this conclusion is based will be given later. The coagulant acts by clarifying the water in the manner presently to be discussed, while the floc formed in the water as a result of the coagulation is partially deposited in the filters and forms a scum which helps to arrest bacteria, protozoa and plankton. Bacteria are also entangled in the floc. A large part of the iron is precipitated and the physical appearance of the water, its colour and transparency are greatly improved. But a difficulty arises during rainy weather when the turbidity of the water is increased by excess of suspended matter. The small settling basin of 445,000 gallons capacity through which the water is passed before it reaches the filters is not really a settling basin at all. It should be called a mixing basin, serving the purpose of bringing the added coagulants into intimate contact with the whole body of water under treatment. The greater the amount of agitation and turbulence that can be created in a mixing tank the better the mixture resulting and the more effective the action of the chemicals will be; moreover, turbulence can be shown to greatly accelerate the rate of floc formation, which is exceptionally slow in the case of a water so deficient in electrolytes as that of Labugama. In many modern waterworks the turbulence in the mixing chamber is artificially increased by the use of paddles and other mechanical aids to the motion of the water. Thus a mixing tank has precisely the opposite function to a settling basin. The present basin represents an ineffectual attempt to combine the two functions of mixing and sedimentation. Holding about 50 minutes supply and subject to considerable short circuiting of the current of water which flows through it, there is no time for proper settlement. The result is that the filters are overtaxed whenever the water becomes really turbid.

Even without a coagulant frequent washings of the filters are necessary to relieve the rapid choking due to deposition of the quantities of suspended matter which reach the surface of the filters under the wet weather conditions already described. This matter includes precipitating iron and plankton which has passed the copper screens within the straining shaft.

These frequent washings tend to lower the level of the water in the clear water basin, since each filter requires 25,000 gallons of clear water for each wash. Hence it is sometimes difficult to maintain the supply without opening the bye-pass to the filters even when no coagulant is used; with a coagulant it would be impossible. Yet this is just the type of water that ought to be both settled and efficiently filtered.

The writer has carefully considered this problem and sees no possible solution but one, the installation of a proper settling basin auxiliary to the tank in use at present. Two-thirds of the existing tank might be converted into a mixing basin pure and simple and connected with the inlet of the new settling tank, the last third would serve the filters as at present and be connected with the outlet of the settling tank. The capacity of the tank required to reduce the rate of flow to the minimum required for settlement of all the gross particles which may be suspended in the water is a problem in hydraulics, on which the writer is not competent to express an opinion, but it must be such as to enable the effective formation of floc and its sedimentation from any water likely to be met with in practice.

A number of observations have been made on floc formation with varying doses of coagulant added to water in glass cylinders both in this laboratory and in that of the City Analyst. Owing, probably, to paucity of electrolytes and particularly of salts of high valency the rate of flocculation is abnormally slow. It can be greatly accelerated by adding a small dose of salt or calcium chloride. Increasing doses of alumino-ferric correctly neutralized diminish the time required to form a floc visible to the naked eye, and for complete clarification. The reddish brown precipitate settled out of the clarified water contains a large proportion of the iron, much colloidal organic matter, and many bacteria entangled in the floc. Chemically and bacteriologically the best results were obtained by neutralization with sodium aluminate, then with the Magadi soda and next with lime (not in excess).

On an average it is estimated that $\frac{1}{2}$ gr. per gallon of alum cake would suffice with a settling tank having a minimum capacity of 3,000,000 gallons and a mean flow of 12,000,000 gallons per diem. The cost per mensem of the chemicals has been estimated by the City Analyst as follows:—

| | Rs. |
|--|-------|
| Alum cake and sodium carbonate | 2,100 |
| Alum cake, sodium carbonate, and local lime | 1,800 |
| Alum cake and burnt lime (33 per cent) | 1,500 |

It will be necessary to subdivide the proposed settling basin so that when the water is of low turbidity only part of the tank is brought into use, and also to permit of its being cleansed in sections. If the floc produced by the addition of coagulant is completely precipitated in the settling tank it will not be possible to establish a film of coagulated aluminium hydrate on the surface of the filters with an average water. The best procedure will probably be somewhat as follows:—

Towards the end of the run of the filters shut off several sections of the new settling tank so that a water holding a heavy precipitate of aluminium hydrate together with some unsettled plankton is passed on to the newly worked filters as soon as washing is completed, that is to say at the time when their filtering efficiency is at a minimum. Continue to pass such a water until the filter shows a loss of head of, say, two feet on the gauge registering resistance to filtration, then open out all the compartments of the settling basin and pass a fully sedimented water on to the filters. In this way a high filtering efficiency could be combined with a long run of the filters thereby saving wear and tear of machinery and labour costs.

The question now arises will coagulation in a proper settling basin suffice to solve the problem of how to deal with the water at its worst, *i.e.*, when its acidity and iron contents are very high and when taste and odour has appeared as a result of the very exceptional conditions already mentioned. It is to be feared that the answer is in the negative. The writer has attempted to neutralize the acidity of water drawn off from the 37 feet sluice and obtain complete clarification when the Ph was 5.6. The quantity of chemicals required was altogether excessive.

It is true this type of water will seldom be met with in practice but even so it seems clear that it will not be economical to depend on chemicals alone for neutralization of acidity and iron precipitation. Fortunately, a great excess of iron can be reduced to a moderate, economically precipitable amount by the simple and inexpensive expedient of spraying the water over a bed of coke or coral.

A series of experiments have been carried out with model scrubbing filters of this type erected over the settling basin by the Waterworks Engineer. "Spraco" jets were used for spraying the water over the 6-inch deep wooden trays with copper meshed bottom holding the small pieces of coke and coral. The drops of water exchange gases with the atmosphere during the period they are projected into the air, carbon dioxide, methane, and sulphuretted hydrogen are given up and oxygen taken in. A still more effective exchange probably takes place during the period when the thin films of water are trickling over the lumps of coral or of coke.

As regards the choice of material for the scrubbers, both materials have their advantages. The surface of the coral scrubber kept continuously white and clean owing to the continual disintegration of the surface layers by the action of the acid water spray. Coral seems more effective as a neutralizing agent than coke and it does not require washing, a great advantage, but coke has special properties in certain forms which will be discussed in a succeeding section.

It has been found that simple contact of the Colombo water with an active coke for a very brief period removes any taste and odour present and also greatly reduces its power of crust formation upon pipes. The difficulty in practice is to maintain the action of the coke. Coke exposed to air on a scrubber remains active much longer than coke submerged in the water. In the latter case the surface of the coke speedily becomes covered with an organic slime, its pores are clogged and all action ceases. In the case of an open scrubber it is possible to spray or cascade the water on the material with sufficient force to make the apparatus almost self-cleansing, and slimy growths develop much more slowly. When the action is lost it can be restored by heating in a current of air at 600°C or in a current of super-heated steam at 850°C. Reactivation or alternatively the renewal of the coke, would be required periodically, but the length of life of active coke could probably be greatly increased by the intermittent application of chlorine to the prefiltered water. The chlorine would be absorbed by the coke and any excess over the amount required to kill organisms upon the coke surface and keep it clean would be given up to the water. In this connection it may be mentioned that the expedient of prechlorinating a mechanically filtered water is extensively used in America. In America longer filter runs have at times resulted, and according to Weston and Howard a saving in coagulant has been effected without impairment of colour removal. (Waterworks Practice, p. 180.) Liquid chlorine is also applied to the raw Thames water in the Staines aqueduct before filtration. In London there has been a marked saving in the cost of cleaning slow sand filter beds. Intermittent prechlorination has a further advantage, it reduces growths on the walls of the prefilter tanks. This is an important desideratum in the case of the Labugama works, where, as will be shown, passage through these tanks is apt to add polyzoa, larvae of insects, bacteria and all their products of decay to the water before it reaches the filters.

The following scheme is proposed for the treatment of the water before coagulation. Let the water be sprayed or cascaded over shallow trays of coral and coke on an aerator platform. The number of tiers of trays would depend on the head of water available over the platform. The water would spout into the air out of holes or jets in a pipe at the apex of the step pyramid formed by the double cascade and descend with some force on the top step whose trays should be filled with $\frac{1}{2}$ -inch pieces of coke. This tray would be self-cleansing. When taste and odour occur in the water coke should be placed in the trays mounted below, but ordinarily the writer would recommend coral which does not need forcible spraying to keep it clean. Most of the aeration and absorption of crust promoting organic substances would occur at the first step, most of the iron precipitation and acid neutralization at the lower ones.

The water collected on the aerating platform would then be run off into the inlet end of the mixing basin, sufficient semi-neutralized alum would be added to clarify the water and enough lime to bring it slightly on the alkaline side of neutrality. As a rule the coral cascade would have already achieved this object and it would not be necessary to add more than a very small dose of lime, if any.

As regards the mode of addition of the coagulants, though the method is somewhat old fashioned, the present vats might be used for the delivery of regulated doses of semi-neutralized alum. The lime could be added in powder form by means of a tipping machine; the City Analyst suggests that this might be regulated automatically through an electric relay operated by a hydrogen ion potentiometer with suitable electrodes immersed in the clear water basin. Such a potentiometer, designs for which are already at hand, could be set to add lime till the Ph. reached, say, 7.4 and then cut it off and on maintaining the reaction of the town water at a constant figure. A simpler method would be to rely on the potentiometer to signal excess or defect of lime and regulate by hand accordingly.

It should be explained for the benefit of lay readers that if the water is not kept at the right reaction all the alum will not be precipitated and some will pass into supply. Alum is a constipating salt capable of corroding the pipes and unsuitable for human consumption; no trace of it should ever enter the mains. Alum alone cannot be added to an acid water, such as that at Labugama, as it can to many others containing sufficient alkaline earths to precipitate any dose of alum likely to be required for clarification or decolorization. Further, an acid water will tend to take up poisonous metals from copper and lead pipes.

Supplementary methods are available for neutralizing the acidity of the water. Thus at the suggestion of Mr. Purves, Assistant to the City Analyst, broken coral has been placed in hollows of the cascade. This will help a little, though as the flow of water down the cascade is at a minimum in the dry weather when the acidity is greatest the effect will be intermittent. Similarly bags of lime or chalk could be emptied into the reservoir near the straining shaft.

Only one of these proposals for improving the treatment of the supply involves any considerable expense, namely the provision of a settling basin.

The costs of liming, chlorinating and potentiometer control plants are insignificant in comparison with the benefits which would accrue from their use; Rs. 45,000 at most.

The writer pointed out in 1920 that the purest water bacteriologically was that near surface of the lake. The installation of a hinged floating arm was suggested or the insertion of additional sluices gates in the straining shaft. He understands that the latter proposal is much simpler from an engineering point of view. The insertion of an additional draw-off between spill level and the 13-foot sluice would certainly effect a great improvement in the average quality of the water supplied during the year and would also save coagulant and extend the average run of the filters.

The Rapid Mechanical Filtration Plant.

Ten Jewell low type gravity filters were put into use in January, 1917, after a preliminary series of tests by the Director of the Bacteriological Institute. At that time the writer was absent on war service. The filters are 21 feet in diameter and each pass 850,000 gallons per day, *i.e.*, about 100 gallons per square foot per hour or 120 cubic metres per square meter per day corresponding to 106 million gallons per acre per day, *i.e.*, about 58 times the rate of a slow sand filter.

In January, 1925, two filters were added, and in January, 1928, the present installation of 15 filters was in operation with a total maximum delivery of 12,750,000 gallons per day.

Each filter consists of a bed of sand 3 feet deep resting on a layer of gravel in which the draw-off pipes with their screened lateral openings are embedded. The water is brought up through a circular space surrounding the filter, the flow into the supernatant water being so directed as to avoid any disturbance of the surface film. A constant velocity of flow is maintained by a Weston controller. A gauge indicates the loss of head due to the increasing resistance from clogging of the sand bed during each run of the filter and hence the time when washing is required. Washing is effected by causing a current of filtered water from an elevated tank to flow through the filter in the reverse direction while the sand bed is stirred mechanically with revolving rakes; about 25,000 gallons are required for washing each filter. After washing is complete the water from the settling basin is once more passed on to the surface. The wash water, and the rewash, *i.e.*, first portion of the filtered water are run to waste.

The efficiency of this type of filter depends upon the formation of a filtering skin on the surface layers of the sand.

The filters were designed to operate with an artificial film formed by the deposition of flocs of aluminium hydrate on the surface. In the majority of waters such a film is readily obtained by simple addition of a small dose of aluminium sulphate or almino-ferric to the water in the settling basin. The carbonates of the alkaline earths (calcium and magnesium) combine with the aluminium sulphate precipitating the aluminum hydrate and liberating carbon dioxide. As the gelatinous hydrate coagulates in the settling basin it entangles and absorbs much of the finer suspended matter and bacteria. A proportion of this coagulum is deposited in the settling basin and the remainder carried by the partially clarified water on to the filter. A settling basin of suitable dimensions therefore should form part of the filtration plant.

Unfortunately, the water of the Labugama lake is extraordinarily soft and very deficient in alkaline earths. There is only enough of them in a gallon of water to neutralize 1/20 gr. of alum. The amount of electrolytes, such as the chlorides of sodium potassium, magnesium, &c., is also small which tends to diminish the rapidity of floc formation. Hence in order to obtain a proper aluminium hydrate film on the filters, it is necessary to add to the water not only alum but also an alkali such as lime or soda. But when this was first done a further difficulty came into play. The ten filters originally installed were barely sufficient to pass all the water required even at maximum rates of filtration without a coagulant. The effect of adding artificial coagulants in sufficient

quantity to form an effective film was to slow down the rate of filtration and shorten the run of the filter to an extent which made it impossible to maintain the supply despite continuous washing. This difficulty has been overcome by providing more filters. The fifteen filters now installed permit of the use of coagulant.

Up till this year, on account of the inadequate number of filters, no attempt has been made to run them continuously with a coagulant. Reliance has been placed upon the natural plankton film formed upon the surface of the sand and upon the adsorptive power of the organic coat formed on a large proportion of the sand granules after the filter has been in use for a period as a purely mechanical strainer. Under these conditions, the sand bed becomes much more deeply impregnated with living and dead matter than is normal for a filter working with an effective coagulant film. The results obtained from a section of No. 9 filter taken six hours after washing are shown below. The sand bed was four years old. Samples of sand were taken aseptically from each layer. Ten grammes of each sample were introduced into a sterile flask with 100 c.c. of sterile water and well shaken.

The counts from this water-suspension were made after 48 hours incubation at 37°C.

Colonies per Gramme of Washed Sand.

| Depth. | | Agar. | | Bile Salt Lactose, | | Relative Volumes of Centrifuged Deposit. |
|-----------|-----|--------|-----|-----------------------|-----|--|
| Surface | ... | 29,600 | ... | 3,770 | ... | 16.0 |
| 6 Inches | ... | 15,500 | ... | 2,300 | ... | 4.2 |
| 18 Inches | ... | 3,240 | ... | 125 | ... | 2.5 |
| 24 Inches | ... | 4,780 | ... | 155 | ... | 2.0 |
| 30 Inches | ... | 4,200 | ... | 85 | ... | 1.5 |
| 36 Inches | ... | 3,400 | ... | 220 | ... | 1.6 |

Iron bacteria, including *Leptothrix*, *Crenothrix* and a few *Spirophyllum* like threads were present in all layers but in much greater abundance in the first six inches. The bulk of the protozoa were also arrested near the surface but statoblasts of the Polyzoon, *Fredericella indica*, were found even at the bottom.

Similar tests made with a similar filter by Bitter at Alexandria and by Schreiber at Berlin working with effective doses of coagulant showed that the deeper layers were relatively less impregnated with bacteria.

Over 95 per cent. of the bacteria may be removed from a turbid water showing a high bacterial count by rapid mechanical filtration combined with suitable treatment with a coagulant. As a rule, the higher the count the greater the proportion of organisms removed.

It is very doubtful whether such a large proportion of the bacteria in the incoming water could be regularly removed from the Labugama lake water. The filtration plant can only be relied upon to remove the majority of any microbes of water-borne disease which might chance to gain access to the lake water. Hence the need for disinfection of the filtered water with chlorine to make it absolutely safe for human consumption in case of "accidental" pollution of the lake.

This combination of rapid mechanical filtration plus chlorination is now very extensively employed all over the world. In fact it is probably the favourite method of treating polluted water supplies. The water is improved chemically and physically by coagulation, the grosser impurities and the bulk of the bacteria are filtered off, while any possibly harmful germs which get through are killed by the chlorine.

In the case of the Colombo works the filters were installed with the primary object of removing crust-forming bacteria and suspended matter.

Leptothrix ochrea, the principal iron bacterium participating in the formation of the incrustation is comparatively large *Fredericella indica*, the polyzoon, giving rise to the masses of suspended matter which formerly passed over the spill of the Maligakanda reservoir is larger still: such organisms in their mature state are easily arrested by the filters even when working without a coagulant; some of the reproductive forms of the iron bacterium, however, such as the conidia and motile threads described by Ellis, would certainly pass through in fair numbers.

Prior to the installation of the filters, polyzoa grew freely on the walls of an experimental pipe in the laboratory through which water constantly flowed. They are never seen now. Yet the brown incrustation which formed on the walls of the glass pipe connected to the main inlet pipe of the filter house showed numerous statoblasts of polyzoa. On other hand, iron bacteria can still be found on the gelatinous surface film which covers the interior of such experimental pipes.

The great majority of the "plankton" organisms listed in a previous section are arrested by the filters. Sir Alexander Houston found in his experiments with rapid filters for the Metropolitan Water Board that the larger plankton organisms in the London water supply were almost entirely arrested with a rate of filtration double that used at Labugama without the use of a coagulant.

Filtration without coagulant has markedly reduced the rate of incrustation of the wall of experimental cast-iron pipes but has not prevented it. It would seem desirable that the filters should constantly operate at the highest level of bacterial efficiency obtainable with the available plant, not only with a view to the reduction of iron bacteria, but also the elimination of amoebic cysts. The diameter of the "minutissima" race of *E. histolytica* cysts is given by Dobell and O'Connor as 6.8 micro-millimetres. Seeing that they are of spherical form their volume and

resistance to filtration would be enormously greater than that of either the average bacterial cell or the conidia of the iron bacteria. Numerous observations and experiments have been made on the filtration plant in conjunction with the City Analyst and the Waterworks Engineer with a view to ascertaining the best working methods. The more significant microbiological results are shown in the succeeding Schedules.

Effect of Filtration with Natural Plankton Film.

| MARCH 26, 1920 :—Dry Weather. | | | Colonies per c.c. in 48 hours at 37°C. | | |
|-------------------------------|---|-----|--|--|----|
| Inlet End. | | | Agar. | Neutral Red Lactose Bile Salt Agar. | |
| 1. | Settling tank | ... | 30 | ... | 3 |
| 2. | Water passing on to filter No. 1 | ... | 60 | ... | 4 |
| 3. | Wash water at start of wash | ... | 9,920 | ... | — |
| 4. | Wash water at end of wash | ... | 640 | ... | — |
| 5. | Rewash water 5 minutes | ... | 1,360 | ... | — |
| 6. | Rewash water 15 minutes | ... | 320 | ... | — |
| 7. | Average sample of all filter cocks at end of run | ... | 20 | ... | 14 |

SEPTEMBER 2, 1920 :—Dry Weather.

| | | | | | |
|-----|--|-----|-------|-----|-------|
| 1. | Reservoir, level of 11 feet draw-off | ... | 1 | ... | Nil |
| 2. | Water passing on No. 10 filter after washing with 25,000 gallons sterilized tank water | ... | 52 | ... | 7 |
| 3. | Wash water at start | ... | 9,300 | ... | 1,820 |
| 4. | Wash water at end | ... | 1,560 | ... | 150 |
| 5. | Rewash water 15 minutes | ... | 780 | ... | 170 |
| 6. | Rewash water 30 minutes | ... | 225 | ... | 6 |
| 7. | No. 10 filter 2 hours run | ... | 440 | ... | 163 |
| 8. | No. 10 filter 5 hours run | ... | 1,280 | ... | 190 |
| 9. | No. 10 filter 17 hours run | ... | 280 | ... | 68 |
| 10. | No. 10 filter 24 hours run | ... | 180 | ... | 55 |
| 11. | No. 10 filter 42 hours run | ... | 51 | ... | 18 |
| 12. | No. 7 filter washed plain water 6 hours run | ... | 160 | ... | 20 |
| 13. | No. 7 filter 39 hours run | ... | 160 | ... | 16 |

SEPTEMBER 13, 1920 :—Dry Weather conditions.

| End of 24 hours run. | | | Colonies per c.c. 48 hours at 37°C. | | |
|----------------------|--|-----|-------------------------------------|-------------------------|-----|
| Reservoir. | | | Agar. | Lactose Bile Salt Agar. | |
| 1. | Twenty-three feet sluice, 10 feet depth below surface | ... | 10 | ... | Nil |
| 2. | Water coming on to filters | ... | 18 | ... | 4 |
| 3. | Filter cocks : Average 10 samples... | ... | 20 | ... | 16 |

APRIL, 1921 :—Wet Weather conditions.

| | | | | | |
|---------------------------|----------------------|-----|-----|-----|-----|
| Six hours run of filters. | | | | | |
| 1. | Settling basin | ... | 493 | ... | 41 |
| 2. | Clear water basin... | ... | 590 | ... | 102 |

APRIL 30, 1928.

| | | | | | |
|--|-------------------------------|-----|-----|-----|----|
| Lake at old spill level. Average conditions. | | | | | |
| End of 24 hour filter run. | | | | | |
| 1. | Lake water in straining-shaft | ... | 116 | ... | 60 |
| 2. | Settling basin outlet | ... | 140 | ... | 64 |
| 3. | Clear water basin centre | ... | 174 | ... | 72 |

Presumptive Coil Test.

APRIL 30, 1928.

| Lactose Bile Salt Broth. | | | | | | | | | | | |
|-------------------------------|---|---|--------|---|---|-----------------------------|---|---|----------|---|---|
| No. I. | | | 1 c.c. | | | 0·3 c.c. | | | 0·1 c.c. | | |
| | + | + | ... | + | + | ... | + | + | ... | — | — |
| | + | + | ... | + | + | ... | + | + | ... | — | — |
| | + | + | ... | + | + | ... | + | + | ... | — | — |
| No. II. | | | 1 c.c. | | | 0·3 c.c. | | | 0·1 c.c. | | |
| | + | + | ... | + | + | ... | + | + | ... | + | — |
| | + | + | ... | + | + | ... | + | + | ... | — | — |
| | + | + | ... | + | + | ... | + | + | ... | — | — |
| No. III. | | | 1 c.c. | | | 0·3 c.c. | | | 0·1 c.c. | | |
| | + | + | ... | + | + | ... | + | + | ... | — | — |
| | + | + | ... | + | + | ... | + | + | ... | — | — |
| | + | + | ... | + | + | ... | + | + | ... | — | — |
| + + Acid and gas in 24 hours. | | | | | | + Acid and gas in 72 hours. | | | | | |

Characters of lactose fermenters isolated from bile salt lactose broth after 18 hours at 37°C.

| No. I. | Motility. | Lactose. | Saccharose. | Dulcite. | Adonite. | Indol. | Methyl red. | Vosges Proskauer. | Kosers citrate. | | | | | | | | | |
|----------|-----------|----------|-------------|----------|----------|--------|----------------|----------------------|--------------------|---|-----|---|-----|---|-----|---|-----|---|
| 1 | ... | + | ... | + | ... | — | ... | + | ... | — | ... | + | ... | + | ... | — | ... | — |
| 2 | ... | — | ... | + | ... | + | ... | + | ... | + | ... | — | ... | — | ... | — | ... | + |
| 3 | ... | + | ... | + | ... | + | ... | — | ... | — | ... | — | ... | — | ... | + | ... | + |
| 4 | ... | + | ... | + | ... | + | ... | + | ... | — | ... | — | ... | — | ... | — | ... | + |
| 5 | ... | + | ... | + | ... | + | ... | + | ... | + | ... | — | ... | — | ... | + | ... | + |
| 6 | ... | + | ... | + | ... | + | ... | + | ... | + | ... | — | ... | — | ... | + | ... | + |
| 7 | ... | + | ... | + | ... | — | ... | + | ... | — | ... | + | ... | + | ... | — | ... | — |
| 8 | ... | + | ... | + | ... | — | ... | + | ... | — | ... | + | ... | + | ... | — | ... | — |
| 9 | ... | + | ... | + | ... | + | ... | — | ... | + | ... | — | ... | — | ... | + | ... | + |
| 10 | ... | — | ... | + | ... | + | ... | — | ... | — | ... | — | ... | — | ... | + | ... | + |
| No. II. | | | | | | | | | | | | | | | | | | |
| 1 | ... | + | ... | + | ... | — | ... | + | ... | — | ... | + | ... | + | ... | — | ... | — |
| 2 | ... | + | ... | + | ... | — | ... | + | ... | — | ... | + | ... | + | ... | — | ... | — |
| 3 | ... | — | ... | + | ... | + | ... | + | ... | — | ... | + | ... | + | ... | — | ... | — |
| 4 | ... | — | ... | + | ... | + | ... | + | ... | + | ... | — | ... | — | ... | — | ... | + |
| 5 | ... | + | ... | + | ... | — | ... | + | ... | — | ... | + | ... | + | ... | — | ... | — |
| 6 | ... | — | ... | + | ... | + | ... | — | ... | + | ... | — | ... | — | ... | + | ... | + |
| 7 | ... | + | ... | + | ... | — | ... | + | ... | — | ... | — | ... | + | ... | — | ... | — |
| 8 | ... | + | ... | + | ... | + | ... | + | ... | — | ... | + | ... | + | ... | — | ... | — |
| 9 | ... | — | ... | + | ... | + | ... | — | ... | + | ... | — | ... | — | ... | + | ... | + |
| 10 | ... | + | ... | + | ... | + | ... | + | ... | + | ... | — | ... | — | ... | + | ... | + |
| No. III. | | | | | | | | | | | | | | | | | | |
| 1 | ... | — | ... | + | ... | + | ... | + | ... | — | ... | + | ... | + | ... | — | ... | — |
| 2 | ... | + | ... | + | ... | — | ... | + | ... | — | ... | + | ... | + | ... | — | ... | — |
| 3 | ... | + | ... | + | ... | + | ... | + | ... | + | ... | — | ... | — | ... | + | ... | + |
| 4 | ... | — | ... | + | ... | + | ... | + | ... | + | ... | — | ... | — | ... | — | ... | + |
| 5 | ... | + | ... | + | ... | — | ... | + | ... | — | ... | + | ... | + | ... | — | ... | — |
| 6 | ... | — | ... | + | ... | + | ... | + | ... | — | ... | — | ... | — | ... | — | ... | + |
| 7 | ... | + | ... | + | ... | — | ... | + | ... | — | ... | + | ... | + | ... | — | ... | — |
| 8 | ... | + | ... | + | ... | + | ... | + | ... | + | ... | — | ... | — | ... | — | ... | + |
| 9 | ... | — | ... | + | ... | + | ... | — | ... | + | ... | — | ... | — | ... | + | ... | + |
| 10 | ... | + | ... | + | ... | — | ... | + | ... | — | ... | + | ... | + | ... | — | ... | — |

It will be noted that in almost every instance, no matter what the condition of the lake water, the effect of filtration without a coagulant is to increase the number of bacteria. The increase begins in the settling tank or even in the straining-shaft and additional bacilli are gathered from the filter bed. A still greater increase often takes place during the flow of the water down the pipe line to Maligakanda or Elie House service reservoirs and sometimes in the reservoir itself. The count in the service pipes depends upon the condition of the pipe wall. Thus if vigorous flushing of the main is in progress after a period of drought, or if for any cause such as shutting or opening of valves in the main pipe line the smooth flow of the water is interrupted, the organic film coating the interior of the pipes is disturbed, and there is an increase in the bacterial count of the water. If the settling basin be emptied and the walls examined they will be found to be coated with an organic film containing a great variety of organisms. When, as sometimes happens, polyzoa appear in great profusion and then die out, a great increase in the bacteria count of the water may be produced as a result of decomposition of the polyzoon colonies.

There is no evidence of any multiplication of true faecal bacteria of lake origin in the waterworks. It would appear that filtration has usually but little effect on the relative numbers of the different types of *B. coli* present in the water of the settling basin. Under dry weather conditions, however, it is clear that passage through the settling basin and even through the straining-shaft and lead to settling basin adds to the number of lactose fermenters, and especially the late lactose fermenter, *B. cloacæ*. The number of colonies of this species sometimes recoverable from filter washings during dry weather is so great that it is difficult to escape the conclusion that this organism actually multiplies in the bed of the filters, probably in the gelatinous organic film covering the sand grains.

The hygienic significance of *B. cloacæ* and its role as an indicator of effective self-purification has already been discussed. If it be a fact that certain organisms, including lactose fermenters, are able to multiply to a disproportionate extent in the waterworks, it will be clear that ordinary tests based on the number of bacilli in the influent and effluent water or on the number of gas forming organisms in lactose or glucose broth will fail to show the actual number of microbes passing the filter. Some bacteria may be arrested and others may be added to the water as it passes down through the filter sand.

This fallacy in bacteriological tests of sand filters has been realized and taken into account by several workers.

The difficulty may be overcome by artificially adding a harmless bacterium to the influent water which may easily be recognized and counted in plates of culture media or in broth dilutions inoculated with the water.

B. prodigiosus is the organism most commonly used. It forms scarlet colonies. Unfortunately, the colour is not well developed except in surface colonies exposed to air so that the counts tend to under-rate the added organisms actually present. For the purpose of the series of tests to be described, a strain of *B. lactis aerogenes* isolated from the Colombo Water Supply was used as the test organism. Its advantage is that it forms very large, rapidly growing, characteristic, colonies on lactose bile salt agar. If the plates are poured to a suitable depth practically all the added organisms can be distinguished from those originally present in the water. The natural count of this organism in the lake water seldom reaches one per c.c.

A pipe runs from the alum house to the main, from the settling basin to the filter house. In the experiment on the filtering effect of a natural plankton film an emulsion of the test organism was allowed to flow at an uniform rate down this pipe for a period of 24 minutes. The added bacilli were well mixed with the water passing on to the filters under test. Dry weather conditions.

The counts of the numbers of *B. lactis aerogenes* per c.c. are shown below.

| Water passing on to filters. | | | Test cock filter No. 2, 18 hour run since washing. | | | Test cock filter No. 10, 48 hour run since washing. | | |
|---------------------------------|-----|-------|--|-----|-----|---|-----|-----|
| Time. | | | Time. | | | Time. | | |
| 2'40 p.m. | ... | Nil | 2'49 p.m. | ... | Nil | 2'50 p.m. | ... | Nil |
| 2'45 p.m. | ... | Nil | 2'54 p.m. | ... | 14 | 2'56 p.m. | ... | Nil |
| 2'50 p.m. | ... | 672 | 2'57 p.m. | ... | 94 | 3' 0 p.m. | ... | 12 |
| 2'55 p.m. | ... | 1,020 | 3' 0 p.m. | ... | 185 | 3' 3 p.m. | ... | 73 |
| 3' 0 p.m. | ... | 1,460 | 3'10 p.m. | ... | 240 | 3'12 p.m. | ... | 220 |
| 3' 5 p.m. | ... | 980 | 3'20 p.m. | ... | 140 | 3'22 p.m. | ... | 130 |
| 3'10 p.m. | ... | 440 | 3'36 p.m. | ... | 16 | 3'39 p.m. | ... | 29 |
| 3'20 p.m. | ... | 120 | 3'54 p.m. | ... | 3 | 3'53 p.m. | ... | 2 |
| 3'38 p.m. | ... | 12 | — | ... | — | — | ... | — |

The added organism began to appear in the effluent remarkably soon. The maximum number of bacteria passing the filter in any one sample is about 16 per cent. of the maximum detected in the incoming water. 640 *B. lactis aerogenes* were found per c.c. of a sample of wash water from No. 10 filter. It is reasonable to conclude that the bulk of the added organisms were retained by the filter, even when working without a coagulant, with the comparatively poor plankton film obtained in dry weather.

Effect of Filtration with Lime Treated Water.

An experiment on the effect of the continuous addition of lime to the water was carried out between the evening of September 2, 1920, and that of September 8.

Excess lime in the clear water basin rose to 1'8 grains per gallon on September 3, after which the dose was reduced. After four days tap water contained 0'6 grain of free lime per gallon. These doses exerted a marked bactericidal effect, killed fish breeding in the pipes and affected the taste of the water. The maximum dose of lime reduced the count on agar from 32 to 13, the resistant forms being mainly spore-bearers. *B. coli* and coliform organisms of all types were entirely eliminated from 100 c.c. of the water passing on to the filters, water from the filter cocks, the clear water basin and the town supply.

This method of disinfecting water is well-known as a consequence of the researches of Sir Alexander Houston for the Metropolitan Water Board ; but it is customary to neutralize the excess lime with carbon dioxide gas or other appropriate means after it has exerted its action before passing the water into supply. Consumers may not appreciate a constant beverage of lime water, nor is it to be recommended. Nevertheless, it is interesting to note that during the treatment of the Aberdeen water with excess lime the consumers received 2'17 parts of lime per 100,000 of water as caustic alkali without complaint.

The main objects of the lime addition in this particular experiment were the destruction of iron bacteria and the elimination of iron by precipitation in the settling tank and subsequent filtration. Neither purpose was achieved. Iron reduction did not exceed 30 per cent. and *Leptothrix ochrea* grew quite well in a sample of water containing the maximum amount of free lime.

It was hoped that the precipitated iron would add to the thickness of the plankton filtering film and so improve filtration. On account of the bactericidal effect it was clearly impossible to form any judgment on this score by counts of the bacteria naturally present in the water. An emulsion of *B. lactis aerogenes* was accordingly run in from the alum house to main entering the filter house as in the previous experiment for 18 minutes. To reduce the bactericidal action of the excess lime to a minimum the samples were diluted immediately after taking with nine volumes of sterile water and agar plates poured for counting from the mixture as early as possible. All this work was done in a temporary laboratory by the lake side.

The number of *B. lactis aerogenes* counted are set forth below :—

| | | | Water passing on to Filter No. 4. | | | Water from Filter Cock No. 4. | | |
|-------|------|-----|---|-----|-------|-------------------------------------|-----|-----|
| 10 | a.m. | ... | Nil | ... | 10 | a.m. | ... | Nil |
| 10'32 | a.m. | ... | Nil | ... | 10'34 | a.m. | ... | Nil |
| 10'37 | a.m. | ... | 160 | ... | 10'40 | a.m. | ... | Nil |
| 10'45 | a.m. | ... | 1,840 | ... | 10'44 | a.m. | ... | 2 |
| 10'55 | a.m. | ... | 2,440 | ... | 10'48 | a.m. | ... | 224 |
| 11'5 | a.m. | ... | 352 | ... | 10'52 | a.m. | ... | 351 |
| 11'12 | a.m. | ... | 12 | ... | 10'57 | a.m. | ... | 377 |
| — | | ... | — | ... | 11'7 | a.m. | ... | 406 |
| — | | ... | — | ... | 11'15 | a.m. | ... | 160 |
| — | | ... | — | ... | 11'22 | a.m. | ... | 43 |
| — | | ... | — | ... | 11'33 | a.m. | ... | 22 |
| — | | ... | — | ... | 11'55 | a.m. | ... | 8 |
| — | | ... | — | ... | 12'35 | p.m. | ... | 2 |

The loss of head shown on the gauge at the commencement of the test was 4·2 feet : the filter ceased running shortly after the last sample was taken, the loss of head then being 4·9 feet. The rate of filtration, therefore, was falling off and the resistance of the filtering film maximal. Nevertheless, the maximum number of test organisms passing through was 16·6 per cent. the maximum passing on to the filter. The time taken for some of the *B. lactis aerogenes* to pass the filter may have sufficed for a distinct bactericidal action ; thereby augmenting the apparent filtration effect.

The subsequent experience of other waterworks has shown that too much excess lime is apt to lead to the solution of organic matter from the coating of filter sand granules and of the walls of pipes and basins.

The excess lime method is employed for the treatment of a number of supplies at the present. An excess lime plant has recently been installed on the recommendations of Thresh and Beale for the treatment of the Southend water supply. Lime is added to the water till the initial excess reaches 2 parts per 1,000,000 ; after preliminary treatment with aluminium sulphate the water is passed through a precipitating cone, and then through a secondary sedimentation basin holding 25 hours supply in which the chalk is deposited ; any remaining excess lime is neutralized by treating the water with carbon dioxide gas generated in a coke furnace. The recent introduction by Thresh of the brilliant cresyl blue indicator has greatly facilitated work with excess lime.

If the Colombo Municipal Council could afford to install a sedimentation basin of more than 12 hours capacity an excess lime process similar to that in use at Southend might be applied to the treatment of the Labugama water.

At Accra on the Gold Coast the excess lime method has been successfully used for sterilization of the water from faecal bacteria and for keeping down excessive plankton growths in the storage reservoirs.

Effect of Filtration with Neutralized Alum.

Preliminary experiments having shown that the filters could not be worked for more than a few hours with larger doses of alum, a run with half grain of alumino-ferric per gallon and the equivalent quantity of soda was commenced on September 15, 1920. This dose produced a rapid loss of head. The usual emulsion of *B. lactis aerogenes* was run into the filter main for 24 minutes one hour after alum had reached the filters.

The maximum number of added organisms counted in the incoming water was 700 but this figure is probably unreliable on account of flocculation effects. The counts obtained from filter cock samples are shown below. Start of run 11·5 a.m. :—

| | | | | | |
|------------|-----|-----|------------|-----|-----|
| 11·10 a.m. | ... | Nil | 11·32 a.m. | ... | 122 |
| 11·12 a.m. | ... | Nil | 11·38 a.m. | ... | 162 |
| 11·14 a.m. | ... | Nil | 11·40 a.m. | ... | 176 |
| 11·16 a.m. | ... | Nil | 11·45 a.m. | ... | 90 |
| 11·18 a.m. | ... | Nil | 11·50 a.m. | ... | 15 |
| 11·20 a.m. | ... | Nil | 12·0 a.m. | ... | 14 |
| 11·22 a.m. | ... | 6 | 12·30 noon | ... | Nil |
| 11·24 a.m. | ... | 9 | 1·0 p.m. | ... | 4 |
| 11·21 a.m. | ... | 115 | | | |

On September 10, 1928, a run of seven hours was carried out with one part per million of alumino-ferric and a neutralizing dose of sodium aluminate plus a small dose of lime, less than 1/8 grain per gallon. The loss of head was not appreciable when samples were taken. The results form an instructive example of the increase in the bacterial count which takes place under dry weather conditions. The water of the lake had remained below spill level for the longest time on record, viz., 16 months.

| | | Colony Counts 48 Hours at 37°C. | | | |
|--------|--|---------------------------------|-----|--|----|
| | | Agar, | | Neutral Red Bile Salt Lactose Agar | |
| No. 1. | Sample, lake water level of draw-off | ... | 9 | ... | 6 |
| No. 2. | Sample of bottom lake water 59 feet depth | ... | 120 | ... | 18 |
| No. 3. | Sample of water passing on to No. 1 filter | ... | 38 | ... | 16 |
| No. 4. | Sample, filter cock No. 1 filter | ... | 145 | ... | 63 |
| No. 5. | Sample, clear water basin 2 feet deep | ... | 165 | ... | 74 |

Presumptive Coli Test.

| Lactose Sodium Taurocholate Broth. Acid and Gas in 24 hours at 37°C. | | | | | | | | | | | | | |
|--|---|---------|-----|---------|-----|--------|-----|--------|-----|--------|-----|----------|-----|
| | | 25 c.c. | | 10 c.c. | | 5 c.c. | | 1 c.c. | | 1 c.c. | | 101 c.c. | |
| No. 1. | + | + | ... | + | + | + | sl. | ... | — | ... | — | ... | — |
| No. 2. | + | sl. | ... | + | sl. | ... | + | sl. | ... | — | ... | — | ... |
| No. 3. | + | + | ... | + | + | ... | + | sl. | ... | — | ... | — | ... |
| No. 4. | + | + | ... | + | + | ... | + | sl. | ... | — | ... | — | ... |
| No. 5. | + | sl. | ... | + | sl. | ... | + | sl. | ... | — | ... | — | ... |
| Acid and Gas in 72 hours at 37°C. | | | | | | | | | | | | | |
| No. 1. | + | + | ... | + | + | ... | + | sl. | ... | — | ... | — | ... |
| No. 2. | + | + | ... | + | + | ... | + | sl. | ... | + | sl. | ... | — |
| No. 3. | + | + | ... | + | + | ... | + | sl. | ... | — | ... | — | ... |
| No. 4. | + | + | ... | + | + | ... | + | sl. | ... | + | sl. | ... | — |
| No. 5. | + | + | ... | + | + | ... | + | sl. | ... | + | sl. | ... | — |

The extension of the acid and gas line on prolonged incubation is an indication that late lactose fermenters of the *B. cloacae* type predominate.

Twenty colonies from No. 1 and 2 samples isolated from the 25 c.c. lactose bile salt broth after 18 hours incubation at 37°C all turned out to be typical late lactose fermenting *B. cloacae*. The corresponding 30 colonies isolated from the influent and effluent filter samples showed 18 *B. cloacae* and 12 colonies of a motile bacillus producing acid only and no gas in saccharose, adonite, maltose, glucose, and mannite, liquefying gelatin, growing in Koser's citrate broth, giving a Vosges-Proskauer's reaction, a trace of indol in peptone water and no methyl red reaction.

Alumino-ferric and Sodium Aluminate Run of the Filters.

February 15, 1929. Dry weather. Water 6 foot level drawn from 13 foot sluice.

Dose of alumino-ferric 0.34 per gallon, the neutralizing dose of sodium aluminate brought the total alum salts applied to 0.55 grains per gallon. Ph 7.1 in water passing on to filters, Ph 6.9 in water from filter cocks.

B. lactis aerogenes emulsion run into funnel communicating with main entering filter house at constant rate with aid of full stream of water flowing from No. 1 vat. Flow regulated by Mr. Purves, assistant to the City Analyst, 4 litres in 32 minutes, 1 litre 8 minutes, 2 litres 16 minutes, 3 litres 24 minutes 25 seconds.

Samples taken from water passing on to Filter No. 11 with sterile pipettes and from filter cock of No. 11 filter direct into sterile tubes. Loss of head during experiment 1.9 to 1.0 feet. The samples of water passing on to filter were taken by the writer, those from its filter cock by Mr. David, Superintendent of Waterworks.

| Water passing on to No. 11 Filter. | | | Filter Cock No. 11. | | |
|------------------------------------|-----|--|---------------------|-----|--|
| Minutes. | | <i>B. lactis aerogenes</i> count per c.c. | Minutes. | | <i>B. lactis aerogenes</i> count per c.c. |
| 0 | ... | 0 | 0 | ... | 0 |
| 2 | ... | 0 | 2 | ... | 0 |
| 4 | ... | 1* | 4 | ... | 0 |
| 6 | ... | 1* | 6 | ... | 0 |
| 8 | ... | 32 | 8 | ... | 1* |
| 10 | ... | 86 | 10 | ... | 0 |
| 12 | ... | 110 | 12 | ... | 0 |
| 14 | ... | 150 | 14 | ... | 0 |
| 16 | ... | 222 | 16 | ... | 1* |
| 18 | ... | 248 | 20 | ... | 52 |
| 20 | ... | 192 | 24 | ... | 18 |
| 22 | ... | 164 | 28 | ... | 45 |
| 24 | ... | 218 | 32 | ... | 26 |
| 26 | ... | 234 | 36 | ... | 51 |
| 28 | ... | — | 40 | ... | 7 |
| 30 | ... | 208 | 44 | ... | 32 |
| 32 | ... | 262 | 48 | ... | 43 |
| 34 | ... | 178 | 52 | ... | 15 |
| 36 | ... | 242 | 56 | ... | 2 |
| 38 | ... | 258 | 60 | ... | 5 |
| 40 | ... | 160 | 75 | ... | 1* |
| 42 | ... | 115 | | | |
| 52 | ... | 21 | | | |
| 62 | ... | 7 | | | |

Colonies marked with asterisks are probably derived from lake water. The 28 minute sample was spoilt. Maximum count of influent water 258. Maximum count of effluent water 52. Effluent maximum 20.2 per cent. of influent maximum.

Alum and Excess Lime Run of the Filters.

An experiment with alum neutralized with lime was carried out on similar lines during the night of February 22, 1929.

Water at 7-feet level drawn from the 13-foot sluice treated with half grain to the gallon of alum plus lime (8½ lb. per five minutes). The Ph reached 9.4 for the water passing on and 7.4 at the filter cocks. Water at draw-off Ph 6.8.

The loss of head failed to rise after nearly eight hours run. The 37-foot sluice was then opened and highly coloured water at Ph 5.6 admitted to the settling basin, alum was applied direct to the filters and half grain to the settling tank as before, about one grain in all. It was found that over 6 lb. of lime per minute had to be added to bring the Ph back to the original 9.4. The loss of head still failed to rise and the stock of lime threatened to run out. The 22-foot sluice was then opened and water at Ph 6.1 admitted to the settling tank which enabled dosage of lime required to neutralize the acidity of the water to be reduced. Additions of lime and alum ceased at 9.30 P.M. *B. lactis aerogenes* run started at 10 P.M., the loss of head being only 1.1 foot.

In all these experiments the Weston controller of the filters were regulated to deliver at a rate of 100 gallons per square foot per hour.



INCRUSTED WATER MAIN SHOWING TUBERCULATION OF SURFACE AND THICKER DEPOSIT AT INVERT.

| Water passing on to No. 11 Filter. | | | Filter Cock of No. 11 Filter. | | |
|------------------------------------|---------------------------|--------|-------------------------------|----------------------------|---------------|
| Minutes. | B lactis aerogenes count. | | Minutes. | B, lactis aerogenes count. | |
| zero | ... | Nil | zero | ... | Nil |
| 2 | ... | Nil | 4 | ... | Nil |
| 4 | ... | Nil | 8 | ... | Nil |
| 6 | ... | Nil | 12 | ... | Nil |
| 8 | ... | Nil | 14 | ... | Nil |
| 10 | ... | 13 | 16 | ... | 64 |
| 12 | ... | 116 | 18 | ... | 90 |
| 14 | ... | 210 | 20 | ... | 126 |
| 16 | ... | 460 | 22 | ... | 178 |
| 18 | ... | 510 | 24 | ... | 200 |
| 20 | ... | 420 | 26 | ... | 170 |
| 22 | ... | 370 | 28-38 | ... | plates spoilt |
| 24 | ... | 430 | 40 | ... | 94 |
| 26 | ... | 480 | 44 | ... | 144 |
| 28 | ... | 440 | 46 | ... | 206 |
| 30 | ... | 350 | 48 | ... | 110 |
| 32 | ... | 280 | 50 | ... | 53 |
| 36 | ... | 352 | 56 | ... | 48 |
| 38 | ... | 180 | 60 | ... | 38 |
| 42 | ... | 130 | 70 | ... | 15 |
| 50 | ... | 94 | 80 | ... | Nil |
| 60 | ... | spoilt | — | ... | — |

The plates were prepared by lamplight in the alum house after midnight, seven were spoilt. Plating was done on the spot to obviate bactericidal effects due to excess lime left in the filters. This experiment gave unsatisfactory results. It will be seen that the maximum count of the *B. lactis aerogenes* passing through the filters reached 40 per cent. of the maximum coming on. A distinct excess of lime was present in the filtrate at one time, the Ph reaching 10 as estimated with a thymol blue standard. It is probable that the dissolution of the organic coat of the sand granules by the excess lime more than offset the added resistance to filtration produced by deposition of iron on the filter surface.

The Main Pipe Lines.

As already stated, there are three water mains between Labugama and the service reservoirs to Colombo ; a 30-inch steel and two 20-inch cast-iron.

Two problems arise out of this part of the works, a hygienic one connected with the risk of contaminated water entering a leaking pipe from the ground in which it is laid and the economic one of the loss of carrying power of the mains.

The former problem was first considered in 1913 by Dr. Marshall Philip and the writer ; when it first became clear that *B. coli* was frequently present in the water supply. The Director of the Bacteriological Institute drew attention to it in his report on the Jewell Filter plant. The true solution is the installation of Venturi meters at each end of the mains.

Marked differences in the number of bacteria can sometimes be detected between the water at Labugama and that passing into the service reservoirs, but mere passage through such a long length of pipe line with its coating of organic matter would account for a considerable change in the bacterial flora of the water. If a marked oscillation in the current of water were produced by opening a valve too abruptly or similar cause great numbers of microbes might be detached from the pipe wall even though it remained intact. Hence it is very difficult to trace pollution of this type by bacteriological tests unless the volume of water under observation is known and the rate of flow can be kept constant. It is much more practicable to employ physical means. A meter at Labugama would also greatly facilitate exact dosage of the supply with coagulants. At present the amount of water under treatment is estimated and cannot be precisely determined.

The problem of the cause and cure of the loss of carrying power of the mains, not only between Labugama and Colombo but in the distribution system generally, has engaged the writer's attention, at intervals, for many years. A great number of observations and experiments have been carried out since 1914. It will only be possible to give a very brief summary of them within the confines of this report.

The gradual blocking of the lumen of the pipes which causes, in course of time, so great a restriction in the water carrying power of the mains and so considerable an increase in frictional losses constitutes the principal economic problem of the Colombo water supply. The obstruction was due to a complexity of causes, one of which, the growth of animal moss on the walls of the pipes, no longer operates. It has been cured by the installation of the filtration plant. Masses of the polyzoon, *Fredericella indica* and *Plumatella longicnemis*, are no longer seen in the water so long as the filters are operating. Both these organisms grow on pipe walls, as they did on the experimental one in the laboratory, and form a kind of soft incrustation, fragments of which are readily detached. The hard element of the incrustation, however, is still progressing though at a slower rate than formerly. Before the installation of the filters it took about nine years to reduce the calibre of a 3-inch pipe two-thirds of its original diameter.

According to Professor Campbell Brown, whose paper on "Deposits in Pipes and other Channels Conveying Potable Water" in the Proceedings of the Institute of Civil Engineers, published so long ago as 1904, is a mine of information on the subject, the various deposits found in water channels naturally range themselves into three classes : (1) Incrustations on unprotected or imperfectly protected iron pipes, (2) Deposits on the interior of iron pipes, protected or unprotected, or of other channels through which water is conveyed, wherever the surface is covered by the water, (3) Accumulations of debris in inverts, hollows and irregularities in water channels and in culs-de-sac. For the purposes of this report these causes of reduction in the carrying power of water mains will be termed (1) Corrosive incrustation, (2) Organic incrustation, (3) Accumulated suspended matter.

The incrustations in Class I are due to corrosion of the iron-work of the pipe or of its valves. They begin as minute limpet-like projections dotted all over the pipe, in shape more or less conical, often with a steeper side facing the current. They grow by addition of concentric layers and increase in size and number till they become confluent and form a coating of considerable thickness. Sometimes the crust may be nearly uniform from the commencement. Pipes of small calibre may be completely blocked by this form of incrustation, but in large pipes the thickness is limited to about one and a half inches. If the crust is then scraped away it is renewed as before. Hence it is inadvisable to scrape mains for removing this type of crust since the obstruction is only temporarily removed and the life of the pipe reduced by further and more rapid corrosion of the iron.

The core of the limpets is black when fresh and soft but becomes red on exposure to air; it usually contains both oxide and sulphide of iron; the middle layers are often composed of orange-red ferric oxide sometimes containing iron bacteria; the outer layers are denser, mainly composed of ferric oxide but including hard layers of black magnetic oxide of iron. Here also iron bacteria may be found.

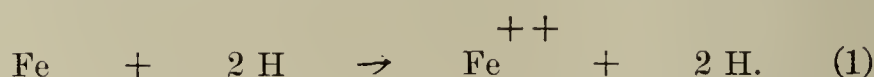
The chief points to be noted about this type of incrustation are that the iron is derived from the walls of the pipe and not from the water; and that if the pipe wall can be perfectly protected by a coating of pitch, patent varnishes, cement linings, bituminous-silicious coatings or bituminous concrete applied centrifugally, no crust will form. In the case of pitch and the patent varnishes, one coat is not enough, pin holes in the first protective layer will expose the pipe to limpet formation.

The true nature of the forces which bring about corrosion is a much debated subject. The writer favours the electro-chemical hypothesis of Whitney. "The whole subject of corrosion is an electro-chemical one, the rate of corrosion is simply a function of electro-motive force and resistance of circuit." "It is not enough then for oxidation solution of a metal that it have a tendency to dissolve (solution pressure due to difference of electro-motive force between metal and solution); it must be in a metallic connection with some other metal capable of acting as an electrode and this second electrode, if a positive element, must have a lower electrolytic solution pressure than the iron."

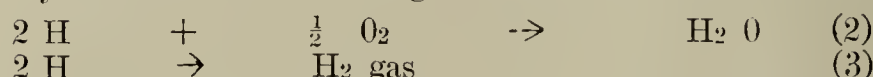
Hydrogen acts as a metal and is electrolytically classifiable with copper as compared with zinc and iron. "If a cell were made up on the Daniel model, iron being used instead of zinc, and hydrogen in place of copper, the cell would generate a current when the iron and hydrogen electrode were connected.

It is well known that iron does dissolve or oxidize in all solutions containing appreciable quantities of hydrogen ions. This electro-chemical relationship between iron and hydrogen is the primary cause of rusting."

Since, according to Whitney, corrosion is a function of H ion concentration it may be prevented by the addition of enough alkali to the water. Thus iron tools or instruments immersed in saturated lime or soda solution do not rust. The fundamental corrosion equation may be represented as follows :—



Now as Walker pointed out, the resulting hydrogen forms a polarizing film which must be disposed of in some way before the reaction can continue. This elimination of hydrogen ions can be brought about by either of two following reactions :—



In practice the latter equation only applies to hot water. What usually happens is that polarizing film is removed by the action of dissolved oxygen in the water according to equation (2). If the water be substantially oxygen free the rate of corrosion is negligible.

Rate of diffusion of oxygen past the surface film on the iron increases with velocity of flow after a certain point. Hence increased velocity of water in pipes tends to promote corrosion.

As regards alkalinity, Wilson considers that with rising Ph. we get three fields. Below Ph. 5 we get evolution of hydrogen, above Ph. 10 or so the alkalinity exerts an appreciable effect in retarding the rate of corrosion. Between these limits there is a stretch where the rate of corrosion is determined by oxygen and is practically independent of the Ph. If this be true it would be necessary to add an excessive amount of alkali to protect the Colombo pipes from corrosion by alkali addition alone. Removal of dissolved oxygen from the water is not desirable so that it would seem that the remedy against corrosion is either the employment of a pipe of non-corrodible material, *e.g.*, reinforced concrete, a rustless alloy of iron (not in the market) or the proper use of one of the protective coatings mentioned above.

A debatable question is that of the part played by iron bacteria in the corrosion of iron pipes. In the opinion of the writer they may tend to promote tuberculation by acting as a scaffold for deposition of rust in their iron absorbing sheaths. In true corrosion the iron of the pipe is dissolved out where the limpets occur and the pipe itself is soft, black, and spongy beneath the limpets.

Turning now to the second of Campbell Brown's types of pipe incrustation. Here the deposit is derived, at all events, principally, from the water itself, as is shown by the fact that it will occur on the walls of a rock tunnel or conduit not made of iron, or, as in the case of the Colombo supply, even on a smooth glass surface.

The best known of the deposits in pipes depending on the composition of the water is that formed of calcium carbonate scale deposited from hard waters containing bicarbonate of lime, as a consequence of the escape of carbonic acid. Campbell Brown states that the ancient Roman aqueduct of Pont du Gard had a lining of this type one foot thick formed in the course of centuries of hard water flow.

The type of deposit which still occurs in Colombo pipe lines is that described as black slime. It contains a great deal of iron. The deposition is not purely mechanical since it may occur evenly all round a pipe constantly running water full bore. It is therefore, strictly speaking, a crust rather than a deposit. The formation of this incrustation in experimental pipes well coated with pitch was closely studied by Campbell Brown. He found that it began as a living and growing jelly adhering to the walls of the pipe. Iron then begins to be deposited, not in, but on the jelly and ultimately long threads appear in the jelly; these threads become sheathed, and then thickened by deposition of iron oxide. The living thread and its sheath elongates more and more. A tangled mass results and becomes denser and more tangled still while all sorts of particles are mechanically entangled. "Finally the organism dies at the older end and breaks down losing its form and becoming a gelatinous flocculent mass of dark ochreous deposit with the younger sheaths and living threads growing out of it." After five months a coating of black slime was formed all round the interior of the pipes containing about 45 per cent. of ferric oxide and 18 per cent. of manganese oxides with much organic matter.

Campbell Brown used water from a rock tunnel which had not come in contact with iron-work. The writer has conducted similar experiments in this laboratory with a 3-inch experimental pipe well coated with pitch, using water from the Maligakanda service reservoir which had passed through a galvanized iron cistern. The organic slime layer, the iron bacterial threads, the ochreous and the black deposit all appeared in due course as described above, but in addition, when the pipe had been run full bore for about nine months, signs of corrosion also appeared, in the form of small limpets scattered about the pipe walls.

True organic incrustation (Type II of Campbell Brown) due to the activities of iron bacteria and other iron absorbing microbes does not in any way affect the pipe wall. The whole crust is super-imposed upon the coat of pitch and when it is carefully scraped away the coat and the pipe appear to be intact. This was the case during the first four months of the Colombo experiments; but later, on carefully removing the pitch coating also it was seen that the pipe itself was slightly pitted showing that a slight amount of corrosion had in fact occurred. It would appear then that the incrustation met with in the Colombo water mains has a two-fold origin and that it is due primarily to the activities of iron bacteria and secondarily to corrosion of the pipes through microscopic imperfections in their protective coating. It is probable, however, that in the case of galvanized iron pipes conveying water to bungalows this sequence is reversed and the corrosive factor becomes the more important.

Campbell Brown made a comparison of a number of natural waters with a view to elucidating the factors favouring the organic type of incrustation. He arrived at the conclusion, which seems fully justified by the data presented, that ferruginous slime in a water supply is invariably associated with two characteristics of the water, (1) acid, other than that due to carbon dioxide in solution, and (2) an appreciable quantity of iron. Crusts of this type were never found in alkaline or neutral waters, so far as could be judged from the evidence afforded by the analysis of 17 British waters, nor were they produced in water containing only a trace of iron. Thus the Lake Vyrnwy water from which Liverpool is supplied showed 0.099 parts of oxides of iron per 100,000 of water. The unfiltered water yields much slime. The surface water is always acid though it contains no carbonic acid or carbonates and no mineral acid. The Elan water sample was very acid contained 0.016 parts of ferric iron and also yielded much slime. Birmingham is supplied from the Elan storage reservoirs. Both these waters showed abundant iron bacteria, photo-micrographs of which are reproduced in the plate annexed to the paper. This work was done before the principal species of iron bacteria had been described by Prof. Ellis, but it seems possible to identify them from the photographs as *Leptothrix ochrea* and *Spirophyllum ferrugineum* the two cosmopolitan iron bacteria found in the Colombo water, whose activities appear to be responsible for the greater part of the reduction which takes in the effective discharge of the water mains. Both the Liverpool and Birmingham waters contain manganese, which appears to be absent from the Colombo water and, apparently, is not essential to this type of incrustation. By contrast take the analysis of the water of the river Dee, Aberdeenshire. This is from a surface with a large area of peat moss but it is almost neutral or slightly alkaline. It forms no slime, the growth in the water channels consists chiefly of fresh water sponges. This water gives rise to a typical corrosive incrustation.

The precise extent to which soluble organic iron containing compounds penetrate into the interior of iron bacteria such as *Leptothrix ochrea* is unknown. Certainly there is much deposition of iron in the gelatinous outer sheath. Iron is not absolutely essential to the growth of the so-called iron bacteria, but it is taken up by them extensively when present. In order to obtain a clear image of iron bacteria grown for some time in iron solutions or one of the walls of pipes it is necessary to clear the preparation by the use of a weak iron solvent acid such as oxalic. The bacterial filaments then show up and can be stained by simple bacteriological dye solutions.

These iron bacteria are easily grown in water containing a trace of iron salts, such as ferrous ammonium sulphate, but they are extremely difficult to isolate in pure culture owing to the tendency of contaminating bacteria to adhere to their sheaths. The writer has not yet succeeded in growing pure cultures of *Leptothrix ochrea* from motile conidia as described by Ellis. The gelatinous entanglement of filaments of iron bacteria and fungi formed on the surface of experimental pipes in this laboratory traps a great variety of plankton forms, particularly desmids, diatoms, and green algæ of the genus *Staurastrum*. The products of their decay in this situation doubtless contribute to the black slime and to the organic matter passing into solution in the water. As already noted *Leptothrix ochrea* (identification confirmed by Prof. Ellis) has been grown experimentally in Colombo water rendered markedly alkaline with excess lime to an extent which sufficed to kill off all *B. coli* present. Campbell Brown tried neutralization of the acidity of the Liverpool water with lime and soda using a modification of the Clark softening process and found that no iron-organism grew in the treated water. He goes on to state, however, that the action of an alkali or alkaline earth does not precipitate the iron oxide; on the contrary, alkali causes the solution of the organic compound of iron by distilled water. He states that he has

never seen slime grow to any extent after good filtration, but that growth of the organic jelly does take place beyond efficient filter beds. The Colombo experience shows that rapid mechanical filtration alone without a coagulant merely delays but does not prevent the organic incrustation. The effect of good filtration through slow sand beds is well shown in the Liverpool experience. The Vyrnwy main 68 miles long is divided into two sections, a short section from the lake to the filter beds and a longer section between the beds and the Liverpool service reservoirs at Prescott. Soon after being put into use the prefilter portion began to diminish in capacity while the post-filter line remained practically unchanged. The reduction amounted to more than 20 per cent. of the capacity of the unfiltered water main.

A special mechanical brush was invented by Deacon with brushes of whalebone operating on the turbine principle which successfully removed the organic incrustation without injuring the nodular incrustations of the corrosive type, and so exposing fresh surfaces to rusting effects. An allowance of 25 per cent. had been made in calculating the discharge of these pipes for the eventual formation of incrustation of the nodular corrosive type.

American authorities have recently succeeded in controlling the growth of iron bacteria by chlorination. The value of chlorine for reducing algal growths was first noted by Honston during his pioneer treatment of the Lincoln water supply in 1905. Nine years ago the writer in his 1920 Annual Report recommended chlorination for the same purpose. It was found, however, that the dose of chlorine required would be large owing to the great absorptive power of the crust-forming organic matter. Plans and specifications were obtained for portable chlorinating motor lorries similar in type to those used in the war, capable of discharging chlorinated water into an isolated section of the mains or into any part of the distribution system. After a preliminary scraping with the scrapers at present in use, it was proposed to chlorinate sections of the pipe line for an adequate period and flush vigorously to waste. But, though economically advantageous, there is a decided danger of objectionable tastes arising from such a drastic treatment as this. It was hoped that this might be obviated by the use of small quantities of sodium thiosulphate and potassium permanganate, but the procedure was complicated and would have required very careful control. Moreover, in 1920-21, when this proposal was under discussion, a regular supply of liquid chlorine, and consequently the modern chlorometer, was not available in the East. It would have been necessary to generate the chlorine at Labugama by the electrolysis of salt solution. In the tropics, however, owing to the difficulty in keeping the electrodes at a low enough temperature, an economical yield of available chlorine is not usually obtained by this means. At that time it was not considered necessary to continuously chlorinate the whole supply.

A number of experiments were carried out in September and October, 1920, on the disinfectant action of sodium hypochlorite generated electrolytically, chloramine T. and chloramine (N. H₂ CL.) prepared after the method of Race by the addition of ammonia to bleach solution; a series of concentrations of each disinfectant were allowed to act on the same batch of *Leptothrix ochrea* recovered by the centrifugalization of a Labugama water which happened to be exceptionally rich in iron bacteria. One c.c. of the concentrated suspension of iron bacteria was added to 250 c.c. of the water plus the various dilutions of the antiseptic. Times of contact before addition of excess of sodium thiosulphate two, three, and four hours.

The results obtained, as judged by subsequent signs of growth of filamentous bacteria, were decidedly erratic as was, perhaps, bound to be the case with samples of such uneven character. The conclusion was reached that consistent arrest of the growth of such bacteria could not be obtained with a smaller amount than 5 parts per million of available chlorine (a very heavy dose). The amount of organic matter, iron and precipitated ferric hydrate in the water used was much in excess of normal, the water being drawn off from the 23-foot sluice.

It may be pointed out, however, that if chlorination of the supply were continuous, instead of being applied intermittently to the mains as originally proposed, a much smaller dose would probably suffice to keep the growth of *Leptothrix ochrea* under control; probably no more than the ordinary dose already proposed for *B. coli* disinfection, viz., 0.25 to 0.3 parts per million.

In 1921 the writer discovered that crust formation on the walls of glass vessels could be prevented or retarded by simply passing the water through a scrubber containing small pieces of coke. All forms of coke are not equally efficacious for this purpose. Judging from the results of recent work it would appear that the effect is very roughly proportionate to the surface adsorptive power of the coke, in other words, what is commonly known as an "active" carbon is required to produce the best results, the criterion of success in this instance being the prevention or diminution of ferruginous slime containing filamentous bacteria of the *Leptothrix ochrea* type in the water after treatment.

Active carbons came with prominence during the war when they were extensively used as absorbents of the poison gases. They are now used fairly extensively for the absorption of excess chlorine from water and for many industrial purposes.

In general, three actions are involved in what McBain has termed sorption: (1) Absorption, *i.e.*, true solution in a solid, (2) Adsorption, *i.e.*, effect due to condensation on surface, (3) Chemical reactions, especially catalytic reactions.

In the first instance the initial solution velocity is rapid but soon falls off, an infinite period of time being required for perfect equilibrium between solvent and solute. On the other hand the pure adsorptive effect is practically instantaneous; any lag being explained, either by interval required for dissipation of heat evolved or by the time required for access of the adsorbable substance to the interior of the pores on the surface of which the condensation takes place. Electro-capillarity effects may modify the surface tension phenomena. The action decreases rapidly with rise of temperature and depends on the extent of surface accessible to the substances adsorbed.

Reactions combining the use of catalysts, such as mineral oxides, with adsorptive action are coming into common use.

Since active carbon adsorbs best at low temperatures it has been much used as an aid to the production of high vacua. Sir James Dewar first used activated coconut charcoal for this purpose as far back as 1875. This charcoal being extraordinarily porous has a very large condensing surface in proportionate to its weight.

Most of the active coconut shell charcoal used in the war by the British services was prepared by the method given by Travers which consists, briefly, in heating just below red heat for several hours till no more vapour is given off, then, raising the temperature to dull red heat for half a minute and then heating in an absorbing tube at 440°C. (boiling sulphur) for several hours in vacuo.

There are various theories, purporting to explain the difference between the surface of an active and an unactivated carbon. Probably activation consists in the conversion of the molecules of unsaturated carbon compounds on the surface of the carbon from a non-polar "resting form" to a polar reactive form. Carbon deposited at high temperatures cannot be activated.

Activation of a carbon may be carried out in a current of superheated steam or air. If steam is used, the temperature range should be between 800°C. and 1000°C., for air somewhere between 350°C. and 450°C. The aim should be to produce a porous carbon at a relatively low temperature as free as possible from inert adsorbed hydro-carbons. For reactivation exposure to a current of steam at 100°C. may be all that is necessary.

The adsorptive power of a charcoal may be tested by immersing it in aqueous solutions of such substances as iodine, oxalic acid, methylene blue, tartar emetic, and quinine sulphate whose concentration before and after exposure to the adsorbent can readily be determined.

Three proprietary brands of active carbon, coke obtained from the Colombo Gas and Water Co. (said to be produced by heating Indian coal in retorts at a temperature round about 650°C.) hard Welsh Foundry coke, inactivated and activated coconut char have been experimented with in this laboratory.

This latter carbon was prepared in the laboratory by heating coconut shell charcoal for several hours at a temperature of 600°C. in air in an electric furnace. The char was contained in a 2-inch diameter silica tube, the variations in temperature being shown by a Wild-Barfield pyrometer in circuit with a thermocouple inserted in the midst of the char.

A series of rough comparative adsorption tests were carried out with weak solutions of iodine, sulphuretted hydrogen, and methylene blue (1-5,000 in distilled water). The methylene blue test gave the most striking results. The foundry coke and inactive coconut char gave little adsorption in one hour. The Colombo coke decolorized as well as a proprietary carbon specially manufactured for waterworks purposes, the best results being produced by a decolorizing carbon sold by a well known German firm. The sulphuretted hydrogen and iodine tests showed a slight superiority of the proprietary waterworks carbon over the local product but not enough to compensate for the difference in price.

After it had been proved by a series of laboratory experiments that treatment with coke had the effect of greatly diminishing the iron-bacterial growth-promoting power of the Colombo water the next step was to try out the method in small experimental plants.

The first series of observations was made in an experimental tank with sand filter attached installed by the Waterworks Engineer behind the Maligakanda service reservoir. Screens of wire and wood containing various cokes were submerged in the water of the tank which was provided with a graduated outlet weir to enable the rate of flow to be gauged. A meter was also connected to the supply pipe. This experiment was unsuccessful. It was found that the coke in the screens speedily became covered with an organic scum which put an end to its activity. By thorough oxygenation of the water the scum formation could be somewhat delayed but even then, despite frequent washings with a strong jet from a hose pipe, the activity had practically disappeared in a fortnight and could only be restored by reactivating the coke. The opportunity was taken to test the effect of submerged coral screens for the neutralization of acidity in the water but the same thing happened; the coral fragments also became coated with an organic slime and ceased to function.

Recourse was then had to the non-submerged coke and coral experimental scrubbers erected over the settling tank at Labugama to which reference has previously been made. The water was sprayed over the scrubbers with "Spraco" jets. This experiment was completely successful. A modification of this method is recommended under the section dealing with the treatment of the lake water.

The action of the coke is not by any means purely one of adsorption of noxious gases, such as sulphuretted hydrogen, or of growth-promoting substances, it accelerates aeration by exposure of the water to an extensive surface thereby facilitating exchange of gases with the atmosphere and it promotes oxidation of organic matter and helps to precipitate iron.

The anti-acid activity of submerged coral can be readily and completely be restored by spraying with a high pressure jet, such as is used for washing the copper screens in the straining shaft. The experiment was tried of inserting coral between the copper guazes of these screens, but the increased weight of a series of screens reaching 60 feet down would necessitate special derricks and the time and labour required to complete the customary screen-washing operations would be excessive.

As already suggested the activity of clogged coke can be prolonged by cascading or forcibly spraying water over the surface and bacterial growth can be kept down by intermittent chlorination. Reactivation of the coke can be accomplished by heating at the appropriate temperature in air or steam.

All the improvements in treatment suggested in the previous section, better filtration, clarification, and chlorination will tend to diminish *organic* crust formation; taken together with aeration over coke and coral they may be expected to afford a complete solution of this vexatious problem as well as effect a vast improvement in the average quality of the water itself.

The incrustation, both organic and corrosive, can be removed from the larger mains by the method already used from time to time, passing a scraper through them every few years, but, as Prof. Campbell Brown points out, it is far better to prevent the growth of slime than to remove it. Moreover, the 30-inch steel main cannot be scraped. Since, however, the treatment recommended will not dissolve an incrustation already formed it will be necessary to use that method on the two 20-inch cast-iron mains once more at least, after the new treatment works are installed. The opportunity should be taken of determining the amount of material removed per mile of pipe. Such data will be helpful in judging the relative share of the corrosive and the organic crust in reducing the rate of discharge through the pipes. Scraping tends to promote corrosion by damaging the protective coat of the pipe. Left to itself corrosion does not progress indefinitely in large pipes the crust itself eventually forming a protective layer when the capacity of the pipes has been reduced to a certain extent. It is possible therefore to compensate for corrosion by employing somewhat larger pipes initially. Alternatively, the pipes may be taken up, lined centrifugally with cement or bituminous concrete with the aid of a suitable machine, or otherwise protected, and then relaid.

There is one physical point connected with the protection of pipe surfaces to which attention may be directed, the possible effect of erosion due to water hammer. Reference may be made to the paper on the subject of S. S. Cock, F.R.S., in the proceedings of the Royal Society p. 481, Series A. Vol. 119, 1928.

Water hammer erosion of galvanized iron pipe surfaces would seem to be particularly important. The forces operating are set up by the collapse of small cavities in the neighbourhood of metallic surfaces and they arise out of the mechanical properties of the nearly incompressible fluid water.

The Service Reservoirs.

These do not call for detailed consideration from a microbiological aspect. They should be well ventilated and at the same time protected from animal droppings. Needless to say, they are closely watched to guard against causal pollution by trespassers. It may be pointed out that chlorination and the other improvements in treatment proposed will tend to diminish growth on the walls and deposit at bottom and lengthen the intervals at which they require to be emptied and cleansed.

The Distribution System.

Four problems appear to arise out of the final stage of supply. (1) The loss of carrying power due to incrustation and corrosion of pipes. (2) The action of the water on copper and lead pipes. (3) The presence of suspended matter in the supply and its deposition in invert and dead ends of pipes. (4) Contamination of the supply through leakage of ground water into the pipes.

The first of these problems has been discussed already under the section dealing with the Main Pipe Lines.

The action of the water on lead and copper falls within the province of the City Analyst who has devoted much attention to the subject. It would appear that the acid Colombo supply has a marked initial action on lead pipes, which tends to cease by degrees as the result of the formation of a protective layer. It is not proposed here to enter into a detailed discussion of the much debated question of the precise mode of action of lead on water. Lead is a cumulative poison which certainly ought not to be present in appreciable quantities in a water supply.

According to Thresh and Beale the solution of lead is primarily due to oxidation by dissolved oxygen in the water. "In the presence of free acid the interaction of oxide and acid forms a salt of lead which if soluble remains in molecular solution." They attach great importance to the protective action of traces of silica as alkaline silicate, which, they maintain, is the only substance which retards lead oxidation and which prevents lead corrosion entirely when the concentration reaches one part per 100,000.

These authorities state that lime, in the absence of silicate in the water, has apparently very little effect in preventing the action of water on lead. Silica treatment is also said to be effective against corrosion in general, including that of iron pipes.

According to the results of a mineral analysis of the total solids in the Colombo water by the City Analyst "silica" is present in the proportion of 1.62 parts per 100,000.

The Waterworks Engineer intimates that he is considering the extensive introduction of copper piping for household connections in place of galvanized iron.

As a consequence of recent improvements in manufacture and particularly methods of jointing which enable strength to be combined with economy of metal, copper pipes can now compete commercially with either lead or galvanized iron; they are much more easily laid than lead, and in the long run much cheaper than pipes of galvanized iron. In Colombo galvanized iron pipes have a short life on account of corrosive incrustation and have to be relaid every few years.

Drawn copper pipes with the new joints are rapidly replacing lead pipes in Great Britain. The action of the water upon copper pipes has been studied by Thresh. The following notes are abstracted from his paper in the *Lancet* 1925, Vol. 1. p. 675.

The action of water on copper is similar to that on lead the metal taking up oxygen from solution and an oxide being found (in the writer's opinion both these actions are primarily electrolytic but this does not affect Thresh's practical conclusions).

Both the solubility of copper oxide and the affinity of copper for oxygen appear to be much less than lead. Traces of copper are present in the human body. It is now well known that wheat, barley and many other articles of food and drink contain copper. Within limits excess of copper is eliminated by the bowels. Lehman (*Archiv. Hygiene* XXIV) has calculated that each individual takes into his body daily 20 milligrammes of copper and Tschirch confirming this adds that so long as the quantity of copper ingested does not exceed 100 milligrammes daily there can be no question of injury to health.

Copper poisoning due to the consumption of excessive amounts of copper is not uncommon in Ceylon where copper laden arrack is sometimes purveyed and where copper vessels are not uncommonly employed in the preparation of highly acid foods. The symptom are those of acute intestinal colic. But copper in minute doses does not appear to be nearly so cumulative in its effect on the human system as lead in similar doses.

As a result of these investigations Thresh arrived at the conclusion that a water can be considered perfectly wholesome if the average amount of copper in the whole day's supply does not exceed 1/10 gr. per gallon or 0.14 parts per 100,000 of the water.

Copper pipes coated with 50 per cent. tin and 50 per cent. lead were found to be as dangerous as lead. The use of such pipes in a corrosive water supply should be strictly forbidden.

Acid waters take up much more copper than those which are alkaline or neutral. The general conclusion arrived at by Thresh is that *copper pipes can be used in all waters that are not acid in reaction. Acid water should never be used until the acidity has been removed by treatment.*

The Colombo water is nearly always slightly acid. In periods of drought its acidity may be marked. It will require neutralization with chalk, soda, or lime before copper pipes can be permitted to come into extensive use. Spraying over coral would usually add sufficient chalk. If the water is chlorinated the formation of an organic protective film cannot be relied upon.

A word of warning is uttered by Thresh which has a special applicability to the Colombo supply at the present juncture.

When an electric current traverses copper pipes any action of the water is enormously accelerated and a perceptibly pale blue deposit forms which dissolves easily in a dilute acid. Copper water pipes must not be used for earthing currents.

In these days of amateur wireless a public warning will be necessary on this point.

Similarly the passage of electric currents leaking from underground cables or the rails of electric trains along water pipes will greatly increase the rate of formation of a corrosive crust—a danger well recognized in waterworks practice.

It would appear that the copper pipes now in use only give rise to two complaints from the consumers.

(1) Green deposit at joints (2) Green staining of porcelain enamel from dropping of taps. "These effects are due to the accumulation of copper oxycarbonate from the evaporation of water and are easily remedied if proper attention is given to taps and joints. They do not necessarily indicate a dangerous condition of the water."

Turning now to the problem of suspended matter and deposit in the town supply, the first point to be considered is the nature of this matter; this again depends on the state of the water. If a large amount of iron is present it tends to gradually precipitate in the water entangling a variety of plankton forms detached from the walls of the pipes. The quantity of plankton depends on the condition of the organic film coating the surface of the interior walls of the pipe, and this depends in its turn on the amount of water available for flushing. The service pipes are regularly flushed with the object of keeping them as clean as possible but in dry weather when water is scarce enough cannot always be spared for this purpose and both plankton and bacteria increase.

Suspended matter and growth flushable from mains tend to accumulate in dead ends and may eventually lead to blockage of pipes opening out from their vicinity. Various species of crustacea may breed in an unflushed pipe; their appearance in bath or drinking water sometimes alarms consumers, though in reality their presence has no more significance than that of the lowlier forms of the animal and vegetable kingdoms constantly present in the water but invisible to the naked eye.

As already indicated, since the filters were installed pipe flora and fauna and suspended matter derived directly from the lake water have greatly diminished. Nevertheless the iron deposit and suspended matter still present in the water remains a great nuisance to many consumers, particularly aerated water manufacturers and makers of ice. In order to avoid the appearance of unsightly deposit in the various brands of aerated waters supplied, all manufacturers install filters of some sort, some of which, such as those made of animal charcoal, are objectionable on hygienic grounds and liable to add bacteria to the water bottled. Moreover, the handling necessary for the maintenance of certain of these filters introduces an element of danger from infection with the microbes of water-borne disease.

One great disadvantage attached to the appearance of visible suspended matter in a water is the encouragement it gives to consumers to maintain domestic filters. No doubt some of these filters are harmless enough if flawless filter candles are used and they are regularly cleansed and properly sterilized. Many, if not most, domestic filters are maintained by servants whose hygienic conscience is by no means tender, and some of whom are bound to be dangerous carriers of some water-borne germ which may easily gain access to the water in the course of misguided efforts to improve its quality. There can be no doubt that these domestic filters should be condemned. If there be the least doubt about the sanitary quality of a drinking water it is infinitely better that it should be boiled rather than filtered.

The instinct which leads the consumer to attempt to purify the town water is not altogether without justification in the light of recent discoveries. Each year brings to light new and hitherto unsuspected dangers. Attention is directed to the work of William Fletcher, late Director of the Institute of Medical Research, Federated Malay States, on Tropical Leptospirosis.

Leptospirae are very common in all sorts of mud and slime met with in natural waters both in the East and West and some strains have been shown to be definitely pathogenic to man, dog, and guinea pig. Rats are believed to be the most important reservoirs of pathogenic leptospirae. Certain cases of "pyrexia of unknown origin" in man in Malaya have been traced to various species of leptospira, one of which, a fatal case, turned out to be the well known *Leptospira icterohaemorrhagiae*, the cause of Weils disease, an infection whose symptoms have some resemblance

to those of yellow fever. Most of the strains were allied to the *L. pyrogenes* isolated by W. Vervoort of Sumatra. Fletcher believes that hitherto leptospirosis has been confused with dengue. In Malaya it is a country disease and there is evidence that the chief source of infection is bathing in muddy streams.

There is evidence that apparently harmless leptospirae may possess pathogenic powers, *e.g.*, Buchanan in the course of an investigation into an outbreak of spirochaetal jaundice in a mine in East Lothian found that the slime on the roof of a damp tunnel contained leptospirae capable of producing fatal spirochaetal jaundice in guineapigs. In this instance the possibility of infection of animal origin seems to have been excluded.

During the period July, 1925, to March, 1926, leptospirae were isolated from the Deptford (Garden) well of the Metropolitan Water Supply, London, some of which after passage through white rats, became pathogenic to guineapigs. This well water is exceptionally pure as judged by ordinary bacteriological and chemical tests. After this disquieting discovery the water was treated by superchlorination and dechlorination (owing to the short period of contact available). Sir Alexander Houston states in his Twentieth Annual Report that leptospirae are easily killed by chlorine. The following paragraph is extracted from his illuminating report: "Recent experiences seems to point at all events to the desirability of avoiding 'dead ends' in a water system, of taking water for drinking purposes direct from the main, and of having cisterns kept clean, covered and inaccessible to rat pollutions. Old defective washers may not improbably be a nidus for leptospirosis, so a dripping tap should, apart from the question of waste, carry a warning of possible danger."

It may well be that future research will disclose latent pathogenic powers in other organisms not uncommonly met with in tropical waters, for example non-lactose fermenters whose characters approximate to those of the Salmonella or Erberthella groups.

The non-lactose fermenters and the typical leptospirae present in the Colombo water supply are still under investigation.

In the meantime attention may be drawn to the experience of several American sanitary authorities who have found that chlorination of water supplies has resulted in a marked improvement in the vital statistics of their water community even though the water supply was not known to be exposed to contamination with the known microbes of water-borne disease.

There are two minor economic disadvantages of the Colombo water supply which are worthy of mention; (1) the unsightly reddish-brown deposit which forms near the bottom of ice blocks frozen in the usual pans employed by ice manufacturers; (2) the adverse action of the town water on certain photographic printing processes. The writer believes that if all his suggestions for the better treatment of the water supply are adopted these economic difficulties will disappear and moreover that it will be possible to economize considerably in flushing water and still keep the mains cleaner than ever before.

Finally there is the question of leaks and contamination of the large and small supply mains from the ground in which they are laid. It should be realized that the subsoil water in many of the low-lying sandy areas on which a large part of Colombo is built is subject to dangerous pollution from the surface. In the case of a low-pressure supply laid in soil exposed to percolation of faecally contaminated surface drainage it is clearly advisable to aim at a high standard of workmanship in laying and testing the pipes and also to place them as far away from sewers as possible. The importance of all this is fully realized by the Waterworks Engineer and his staff. It is with a view to detecting accidental pollutions of this dangerous type that the weekly routine bacteriological tests are made of the standpipe water all over the town. But at present the interpretation of the results obtained is a matter of considerable difficulty owing to the large numbers of lactose fermenters commonly present in the main supply. If the water were chlorinated with a minimal dose of chlorine it would be much easier to detect the grosser forms of pollution due to leaks into pipes since the chlorine normally sufficient to kill off *B. coli* at Labugama would no longer suffice to sterilize a second large dose of pollution after the water had passed through the service reservoirs. If local leaks should be detected the proper course would be to resort to superchlorination of that part of the supply till they were remedied. The production of a taste in the water would, under these circumstances, have to be risked.

The late Medical Officer of Health, Dr. Marshall Philip, many years ago, drew attention to the danger associated with the use of ball hydrants, which cannot be altogether depended on to keep surface pollution from gaining access to the water supply. Throughout the distribution system all ball hydrants have now been replaced by hydrants of the valve spindle pattern.

In concluding this section the following extract may be quoted from a summary on the Eighteenth Annual Report by Sir Alexander Houston: "It is foolish to allow preventible pollutions to reach a supply antecedent to filtration. During, and still more after purification, it is simply madness. There is only one course to adopt. Regard all adventitious water entering a supply during and after purification as anathema. No engineer can gauge the morbid value of these contaminations, and even the most competent of bacteriologists may be incapable of estimating the degree of potential danger."

Summary of Proposals for the Improved Treatment of the Colombo Water Supply.

The recommendations put forward in the body of the report may be classified as shown below. They are ranged in what seems to the writer their approximate order of importance, hygienic considerations being given priority over economic.

THE TREATMENT WORKS.

(a) *Chlorination.*

Advantages:—

- (1) Safety of the water supply assured against contamination with the *microbes* of water-borne disease irrespective of the condition of the watershed.
- (2) Average bacterial state of water brought into conformity with modern official standards.
- (3) Growth on pipe walls diminished, thereby reducing incrustation and organic suspended matter detachable from pipes and economizing flushing water.
- (4) Filter bed plankton brought under control, thereby prolonging life of bed, average run of the filters, and economizing maintenance of filtration plant.

Capital cost Rs. 24,000, Maintenance cost about Rs. 1,200 per mensem.

| | |
|--------------------------|---|
| (b) <i>Storage</i> | } In new tank at treatment works of at least 3 million gallons capacity. |
| (c) <i>Sedimentation</i> | |
| (d) <i>Clarification</i> | |

Advantages:—

Storage.—The great weakness of the present works from a hygienic point of view is the inadequacy of the available effective storage. Storage in the Labugana reservoir is ineffective under present conditions. The provision of a settling tank of only six hours capacity would increase the period elapsing between drawing off the water from the settling tank to delivery to the consumer from 26 hours to 32 hours, *i.e.*, 23 per cent. Supposing it is shown that the supply is subject to contamination with infective cysts of *E. histolytica*, every additional hour's storage would be a material advantage in view of the rapid death-rate of these cysts in water at tropical temperatures.

Sedimentation.—Time would be allowed for settlement of the grosser incoagulable particles of suspended matter in the water, thereby greatly relieving the filters, especially during wet weather when they are overtaxed. All risk of having to bye-pass the water past the filters to keep up the supply would be obviated. By lengthening the average length of the filter runs filtering efficiency would be greatly improved at the very time when it is most important that percentage removal of protozoa and of the reproductive forms of iron bacteria should be at a maximum.

Capital cost dependent on size of tank and site selected, considerable.

Maintenance.—For sedimentation and storage alone there would only be the added cost of periodic cleansing and treatment of the walls.

Clarification.—Of the average water by addition of coagulants, such as alum and lime, would greatly improve its appearance and eliminate much iron and crust-forming matter and many micro-organisms. It would help to reduce the growth of micro-organisms on the pipe walls and the amount of suspended matter in the town supply. The deposition of a floc of aluminium hydrate on the surface of the filters would greatly improve their efficiency.

Capital cost.—If powdered lime or lime water is not used the capital cost would be nil, but it would be advisable to instal a lining apparatus with potentiometer controls at a cost of about Rs. 18,000.

Maintenance charges.—For an average dose of $\frac{1}{2}$ gr. per gallon all the year round using alum semi-neutralized with soda and lime, the cost of chemicals per mensem would be about Rs. 1,800. The daily dose of alum would vary from nil to 2 gr. per gallon.

(e) *Aeration over Coral and Coke.*

Advantages:—

- (1) Elimination of taste, odour, and the bulk of the excess iron in bottom waters.
- (2) Great reduction in crust-forming substances in all waters.
- (3) Neutralization of most and, in some waters all, the acidity, thereby enabling copper service pipes to be installed with perfect safety.
- (4) Great economy of the amount of coagulants required for clarification, especially when water was being drawn off from low levels in dry weather.

The capital cost would depend on the design of the aerator. If this method of treatment is adopted the figure of Rs. 1,800 per mensem already quoted for cost of coagulants could probably be greatly reduced. If coagulants are systematically used it would certainly pay to put in the proposed aerator.

(f) *Provision of one or more additional draw-off sluices in the straining shaft.*

Advantage:—

Increase in the delicacy of control of the draw-off. As a rule the best water is that obtainable between 1 and 3 feet from the surface of the lake. It will be possible to withdraw a lake water of higher average bacteriological and chemical quality if a sluice is inserted in the straining shaft about seven feet below spill level.

IMPROVEMENTS TO THE WATERSHED.

(a) *Provision of silt traps at the outfall of the principal streams entering the lake.*

Advantages:—

Reduction in the amount of vegetable detritus, leaves, twigs, &c., entering the lake and decomposing at its bottom, thereby unduly increasing organic matter in solution and promoting bacterial growth.

(b) *Dredging out the silt already deposited in the shallow bay at the far end of the lake.*

Advantages:—

Reduction of organic matter and growth promoting substances in the water.

At present the safety of the Colombo water depends on the strict preservation of the watershed and of the waterworks from pollution originating from man or from animals suffering from diseases communicable to man.

The responsibility rests upon the Waterworks Engineer. All certificates from the City Microbiologist or the City Analyst that the water is wholesome and fit for human consumption are made on the assumption that the supply is in fact preserved from irregular pollution of the

watershed or waterworks or accidental admixture of contaminated subsoil water through leaks in the pipe lines. In practice no method of chemical or bacteriological analysis known now or likely to be known hereafter can constantly detect pollution of this type in a supply of 12 million gallon per diem.

As already explained in the section on the watershed, there is reason to fear that the water supply *may* be exposed to frequent infection with the cysts of *Entamoeba histolytica*, but in all probability, few, if any, of these cysts will reach the consumer so long as the filters are operating at a reasonably high level of efficiency. At present the filters are grossly overtaxed under wet weather conditions.

Having regard to recent discoveries in microbiology, especially increased knowledge of the carrier state and of diseases of the lower animals communicable to man, the writer is strongly of opinion that at least two additional lines of defence are required to safeguard the Colombo water supply absolutely against the microbes of water-borne disease, viz., chlorination and filtration with a coagulant, and that as many hours additional tank storage should be provided as the Council can afford.

The Waterworks Engineer should continue all his present precautions, patrol of boundaries of the catchment area, supervision of labour force, and protection of the head waters; but such measures are not an absolute safeguard against human pollution.

No human being, however competent, energetic, and well-served he may be, can guarantee perfect administrative control of a large labour force or perpetual preservation of a large catchment area in the neighbourhood of large plantations. With the assistance of modern methods the health of the whole water community can be protected against the consequences of accidental or casual pollution of the supply at a cost which is largely offset by the economic advantages also obtained, such as more prolonged carrying power of the mains.

The position taken up by modern experts in the hygiene of water supplies is that no pains or expense should be spared to enable a perfectly wholesome water to be delivered to the consumers at all times and seasons and that no unavoidable risks should be run of even temporary failure to attain this standard.

Turning now to the economic aspect of the question. Objection may be taken to the expense of the coagulants required for clarification. It should be realized that if the matters coagulated are not deposited in the proposed settling basin they will either contribute to the blockage of the mains or be delivered to the consumer as suspended matter. The treatment recommended is *not* a remedy for *corrosion* of mains but for *organic incrustation* of them, a very different thing. To prevent corrosion the large mains must be made or lined with an incorrodible material, while copper can be used for the household service pipes, provided the acidity of the water is neutralized, as it can be easily and very cheaply. It is quite possible that the organic incrustation will not form on cement lined pipes laid down in place of those in use at present, but it is by no means certain. It seems a case where prevention is better than cure.

It may be argued that the citizens of Colombo, with the exception of those interested in certain trades and industries, are quite satisfied with the physical condition of the present water, therefore, why spend money in attempting to improve it? Certainly, if in purity as opposed to wholesomeness was the sole object in view the argument would have much force, but in this case the question of purity in a chemical and physical sense cannot be divorced from wholesomeness in a microbiological and hygienic sense.

Under the most favourable conditions on the watershed the purity of the Colombo water compares favourably with that of any other in the world. Under the most unfavourable it will only appeal to those who relish a chalybeate water of good substance.

If the recommendations set forth above are adopted the Council should be able to supply a pure and wholesome water under all conditions, one which will not incrust the mains, which will have no action on poisonous metals, which will be free from taste and odour and perfectly safe for human consumption unboiled and unfiltered whatever the weather or the condition of the watershed, and which will be free from visible suspended matter and bright and sparkling to the eye.

In conclusion the writer wishes to acknowledge his indebtedness to many scientists abroad for advice and assistance, particularly Sir David Prain, F.R.S., and Prof. W. J. Hodgetts, for the identification of plankton forms, and to Sir Sidney Hamer, F.R.S., and Dr. Kirkpatrick of the British Museum for information regarding polyzoa. Prof. David Ellis has devoted much time and attention to the Colombo iron bacteria. Prof. Clifford Dobell, F.R.S., has helped with information and advice in the matter of the protozoa of the Labngama monkeys. The fascinating reports by Sir Alexander Houston to the Metropolitan Water Board have proved a mine of information on all aspects of the microbiology of water supplies. Col. Clemesha has from time to time given freely of his great fund of experience of tropical water supplies.

Locally, the writer owes much to the Waterworks Engineer, who has always been prompt in providing whatever experimental facilities and information were required, and to the City Analyst, Mr. C. A. Bruce, whose records and long experience of the chemistry of the Colombo water supply have been freely used, Mr. Purves, his assistant, has on several occasions been of great assistance to the writer in his observations *re* the filtration plant. Mr. Bryan R. Dyer, the Government Sanitation Engineer, Mr. C. T. Symons, the Government Analyst, and Mr. J. W. Hinton, the Professor of Physics at University College, have all helped with literature and advice on technical points.

Finally the writer wishes to pay a tribute to his staff for their faithful assistance in the work itself and the preparation of the report. He has read the well known drama by Ibsen entitled an "Enemy of the People."

L. F. HIRST,
City Microbiologist.

May 17, 1929.

Annexure B.

REPORT OF THE CITY ANALYST FOR 1928.

During the period under review 1,585 samples were examined, of which 1,237 were milk samples, 193 from City water supply, 24 well waters, and 131 miscellaneous.

The monthly index of purity of the milk samples during the year varied from 46 per cent. to 70 per cent. average 60 per cent. Samples falling into the 1-10 per cent. added water scale varied monthly from 15-30 per cent. average 24 per cent.; 11-30 per cent. added water scale varied from 5-18 per cent. average 10 per cent.; over 30 per cent. added water varied from 0.2-13 per cent. average 5 per cent. Maximum added water amounted to 77 per cent. and the monthly variation was 23-77 per cent. There is no periodicity in milk adulteration.

Fat deficiency was noted on an average of 18 per cent. of the samples received, this varied monthly from 8-26 per cent. Samples with a fat deficiency of 1-10 per cent. varied from 2-11 per cent. average 6 per cent.; 11-30 per cent. fat deficiency varied from 3-19 per cent. average 10 per cent.; over 30 per cent. 1-5 per cent. average 2.3 per cent. The maximum fat deficiency monthly variation was 31-63 per cent. Fat deficiency is calculated on the milk as received, not on the unadulterated milk.

Comparing added water figures with fat deficiency, it is noted that added water is found in 40 per cent. of the samples and fat deficiency in 18 per cent., of these, 15 per cent. are gross figures (*i.e.*, over 10 per cent.) for added water, and 12 per cent. gross figures for fat deficiency.

The standard of milk supply in Colombo City is poor as deduced from above figures. Only a fraction of the milk consumed can be tested. The index of adulteration is probably higher than the figures indicate, and is higher than 1927.

The City water supply maintained its high standard of purity throughout the year. Quality fell off slightly during the drought period and later, due to scouring out of the reservoir after an unprecedented drought. In order to visualize the quality of Labugama stored water, samples from the reservoir were taken at a depth of fifty feet. Analyses proved them to be satisfactory. Aeration would have rectified deficiencies as the surface of the reservoir was lowered. If the drought had continued, the high quality of the water would have been maintained. This would not have been so if the reservoir bund had not been raised.

Labugama reservoir was visited and trials were made of precipitation with sodium aluminate along with alum and burnt lime, the reaction or p.H. being controlled. This experimental work was carried out in conjunction with the City Microbiologist, but as the experiments were not conclusive they will be repeated when the drier weather occurs. The object of the experiment is to control iron bacteria in the water supply and further deposition in the water mains.

Well waters were tested to the extent of 24 samples. 14 were condemned as unfit for human consumption, 1 was passed, and 19 returned as suspicious. Such waters are retested.

Samples of the Kelani river have been taken above and below the Madampitiya sewage effluent periodically to determine the pollution of the Kelani river. No serious pollution of the river by Madampitiya sewage effluent is indicated by analyses. This does not mean the Kelani river water is fit for human consumption, either above or below the sewage effluent. Thirty-seven samples of Kelani river water in all were examined.

Wellawatta canal water was tested to determine seepage pollution. This is not a menace at present, but may be in the future. The Wellawatta canal contains salt water by sea infiltration. Eight samples were examined.

The Madampitiya sewage system was visited and ten samples taken and examined during the year. There is a purification of 45 to 50 per cent. in the system from Bell-mouth to effluent. As the effluent is near the mouth of the river a high standard of purification is not necessary. Dilutions of effluent with various proportions of river water were made and determinations of oxygen consuming power and dissolved oxygen were made on the mixture. The figures obtained were satisfactory even at the dilution of one of effluent to twenty-two river water. Old calculations of the dry weather river flow gave a ratio of one effluent to 200 of river water. The dry weather or minimum flow of the river requires to be recalculated as the Flood Scheme is considered to have scoured out the river bed and the alteration of the exit of the river to the sea from south to north may have made a difference to the volume of water flowing past the effluent and consequently the dilution of the effluent. The rate of flow of the river from effluent to sea is also required, to determine the time required for suspended solids to pass from effluent to sea. The time taken for the dilution experiments and oxygen consuming power was four hours, but suspended solids will take a much shorter time than four hours to pass from effluent to the sea, so that the tests are severe.

The Municipal Engineer's Department are carrying out river flow experimental work.

It was suggested that the Detritus tanks, which have never been used, be brought into the sewage system. Either the flow direct from Bell-mouth might be passed through the Detritus tanks and further to the existing septic tanks; or else the present effluent from the septic tanks might be passed to the Detritus tanks utilizing the wall of the existing septic tanks as a wall of the new channel.

Materials for activated sludge experimental work have been in store for some years. As the Municipality may have to fall back on the activated sludge process to accelerate the existing process on the existing plant experimental work should be started at an early date. The small cement tank leading from the old aerobic beds could form the initial activated sludge experimental tank.

The present activated sludge process is an improvement on the original methods, and now that the City Microbiologist has deanchylized the experimental sludge beds at the Lunatic Asylum, Angoda, by the simple expedient of keeping the sludge under glass, large scale experimental work should be carried out for Colombo City on the same lines.

Six samples of bulk arrack were taken from City arrack taverns for determination of copper. Arrack according to Government regulations should not contain more than 0.25 grains of

copper per gallon. Some of the samples of arrack obtained contained nearly three times the allowable maximum of copper and only one fell as low in copper content as the allowable maximum. Government purchases arrack containing not more than 0.25 grains of copper per gallon. Arrack of this quality should be supplied to City consumers. Although new arrack, it is preferable to aged arrack with a high copper content. Arrack with less than the maximum copper content can be produced, as I have proved, using the ordinary arrack plant.

Soda waters were examined for the presence of heavy metals, none of the 38 samples were seriously contaminated. Manufacturers of aerated waters now use block tin pipes. Some of the solders used contained copper and lead, but these factories have been warned to change their solder. If soda water manufacturers have been made to produce aerated waters without contamination, there is no reason why Government should sell copper contaminated arrack and the matter be waived, because Government are the vendors and monopolists.

Three samples of imported milk were tested, one was found to contain boric acid and admitted it on the label. The Medical Officer of Health was asked to report the matter to His Majesty's Customs and have further consignments stopped at the Port. The importing firm was warned. One sample of condensed milk was brown and contained tin. The consignment was recalled by the importer. Imported milks should come up to the legal standard on dilution. One sample of dried imported milk tested did not conform to the regulations for imported milk. There are many such samples of milk imported which are called "Milk Foods." By simply adding the word "Food" after milk, importers escape the Imported Milk Regulations. This matter has been reported to His Majesty's Customs with a view to having the Imported Milk Regulations changed to include milk foods.

Two samples of vinegar made from coconut toddy were submitted. These were found to be genuine coconut vinegars. Complaints have been made that coconut vinegars are made up with dilute glacial acetic acid. This would be difficult to prove unless standards were made and more difficult to prove injurious to public health.

Twelve samples of tea were examined. These were of the rubbishy tea order, that is tea mixed with stalks, fluff, and sand. Extraneous matter varied from 10 to 50 per cent. and gave a low water extract generally about 30 per cent. The samples were not tea in the accepted sense of the word, but it would be difficult to prove their consumption injurious to public health as the extract is made with boiling water. It is better that such "Teas" should be consumed locally than that they should be exported. Probably local consumers could not afford a leaf-tea, and if they could not get a cheap tea they would have to go without. In outstations, where water supplies are doubtful, tea preparation is always a safeguard against water-borne diseases.

Six ice-creams were examined. These are mostly frozen water with a little milk added. Only one sample had a reasonable proportion of fat present, but none were standard American ice-creams with a high food value.

Samples of fæces were sent from the General Hospital from one of the victims of the Pettah Hotel poisoning case. No poison was identified. A copper cauldron was examined which was used in the preparation of food at the hotel. The cauldron was coated with white metal inside. This was tested and found to be ordinary solder which is a mixture of tin and lead. The deposit was worn off at the bottom and showed signs of further wearing. Pure tin should be used for lining such cooking vessels. It is easily applied.

Garbage was received from the Municipal Engineer during the wet weather. As it contained 50 to 60 per cent. moisture there was difficulty and waste of heat in ashing it. Pre-drying the garbage on the flues would utilize waste heat and accelerate ashing.

The Laboratory, Turret road south,
Colombo, January 28, 1929.

ALEXANDER BRUCE,
City Analyst.

Sample Index.

| Months. | Well | | | | Miscellaneous. | Milk. |
|-------------|------|--------|--------|----|--|-------|
| | Town | Water. | Water. | | | |
| January | ... | 16 | ... | — | 7 Kelani river water | 88 |
| February | ... | 16 | ... | 1 | 2 sewages, 1 vinegar, 6 Kelani river water | 106 |
| March | ... | 16 | ... | 2 | 7 soda waters, 3 arracks, 1 vinegar | 100 |
| April | ... | 16 | ... | 1 | 4 soda waters, 1 arrack, 2 ice-creams, 4 sewages, 6 Kelani river water | 105 |
| May | ... | 16 | ... | 2 | 2 Ice-creams, 2 canal waters, 2 soda waters, 4 teas, 1 arrack, 6 Kelani river water | 111 |
| June | ... | 17 | ... | 2 | 2 soda waters, 1 city refuse, 1 tea | 101 |
| July | ... | 16 | ... | — | 5 soda waters, 5 teas, 2 sewages, 1 fruit syrup, 1 arrack, 2 ice-creams, 6 Kelani river water | 98 |
| August | ... | 16 | ... | 5 | 1 canal water, 2 sewages | 104 |
| September | ... | 16 | ... | 4 | 7 soda waters, 3 teas, 1 sugar, 1 flour, 1 burnt lime, 6 Kelani river water, 1 water submitted by Dr. Hirst—Labugama reservoir | 111 |
| October | ... | 16 | ... | 4 | 3 soda waters, 3 canal waters, 1 fæces for poison, 1 cauldron | 105 |
| November | ... | 16 | ... | 1 | 5 soda waters, 1 milk food, 1 condensed milk | 103 |
| December | ... | 16 | ... | 2 | 3 canal waters, 3 soda waters | 105 |
| Total | ... | 193 | | 24 | 131 | 1,237 |
| Grand Total | ... | 1,585 | | | | |

MILK ANALYSES.

Added Water.

| Months. | Total Number of Samples examined. | | 0 per Cent. | 1-10 per Cent. | 11-30 per Cent. | + 31 per Cent. | Maximum. |
|-----------|--------------------------------------|------------------------|-------------|-------------------|--------------------|-------------------|----------------|
| January | ... 88 | { No. of samples | 61 | ... 19 | ... 8 | ... — | } 23 per cent. |
| | | { Per cent. of samples | 69.3 | ... 21.6 | ... 9.0 | ... — | |
| February | ... 106 | { No. of samples | 69 | ... 28 | ... 5 | ... 4 | } 46 per cent. |
| | | { Per cent. of samples | 65.1 | ... 26.4 | ... 4.7 | ... 3.8 | |
| March | ... 100 | { No. of samples | 63 | ... 21 | ... 14 | ... 2 | } 48 per cent. |
| | | { Per cent. of samples | 63 | ... 21 | ... 14 | ... 2 | |
| April | ... 105 | { No. of samples | 74 | ... 19 | ... 5 | ... 7 | } 65 per cent. |
| | | { Per cent. of samples | 70.5 | ... 18.1 | ... 4.8 | ... 6.7 | |
| May | ... 111 | { No. of samples | 67 | ... 17 | ... 12 | ... 15 | } 70 per cent. |
| | | { Per cent. of samples | 60.4 | ... 15.3 | ... 10.8 | ... 13.5 | |
| June | ... 101 | { No. of samples | 62 | ... 21 | ... 10 | ... 8 | } 61 per cent. |
| | | { Per cent. of samples | 61.4 | ... 20.8 | ... 9.9 | ... 7.9 | |
| July | ... 98 | { No. of samples | 51 | ... 27 | ... 14 | ... 6 | } 62 per cent. |
| | | { Per cent. of samples | 52.0 | ... 27.6 | ... 14.3 | ... 6.1 | |
| August | ... 104 | { No. of samples | 67 | ... 27 | ... 9 | ... 1 | } 77 per cent. |
| | | { Per cent. of samples | 64.4 | ... 26.0 | ... 8.7 | ... 0.9 | |
| September | ... 111 | { No. of samples | 51 | ... 33 | ... 20 | ... 7 | } 69 per cent. |
| | | { Per cent. of samples | 46.0 | ... 29.7 | ... 18.0 | ... 6.3 | |
| October | ... 105 | { No. of samples | 69 | ... 24 | ... 9 | ... 3 | } 53 per cent. |
| | | { Per cent. of samples | 65.7 | ... 22.9 | ... 8.6 | ... 2.9 | |
| November | ... 103 | { No. of samples | 59 | ... 30 | ... 9 | ... 5 | } 66 per cent. |
| | | { Per cent. of samples | 57.3 | ... 29.1 | ... 8.7 | ... 4.9 | |
| December | ... 105 | { No. of samples | 58 | ... 32 | ... 13 | ... 2 | } 53 per cent. |
| | | { Per cent. of samples | 55.2 | ... 30.5 | ... 12.4 | ... 1.9 | |
| Total | ... 1,237 | { No. of samples | 751 | ... 298 | ... 128 | ... 60 | } 77 per cent. |
| | | { Per cent. of samples | 60.7 | ... 24.1 | ... 10.3 | ... 4.85 | |
| 1927 | ... 1,157 | { No. of samples | 736 | ... 302 | ... 74 | ... 45 | } 67 per cent. |
| | | { Per cent. of samples | 63.6 | ... 26.1 | ... 6.4 | ... 3.9 | |

Milk Fat Deficiency.

| Months. | Total Milks. | Total below Standard. | | 1-10 per Cent. | 11-30 per Cent. | + 31 per Cent. | Maximum. |
|-----------|--------------|--------------------------|-----------|-------------------|--------------------|-------------------|----------------|
| January | ... 88 | ... 7= 8.0 | per cent. | ... — | ... 3 | ... 4 | 62.8 per cent. |
| February | ... 106 | ... 10= 9.4 | per cent. | ... 2 | ... 6 | ... 2 | 43 per cent. |
| March | ... 100 | ... 21=21 | per cent. | ... 8 | ... 11 | ... 2 | 45.8 per cent. |
| April | ... 105 | ... 13=12.4 | per cent. | ... 6 | ... 6 | ... 1 | 54.2 per cent. |
| May | ... 111 | ... 29=26.1 | per cent. | ... 9 | ... 19 | ... 1 | 39.9 per cent. |
| June | ... 101 | ... 20=19.8 | per cent. | ... 6 | ... 11 | ... 3 | 60 per cent. |
| July | ... 98 | ... 22=22.4 | per cent. | ... 11 | ... 10 | ... 1 | 31.4 per cent. |
| August | ... 104 | ... 22=21.2 | per cent. | ... 9 | ... 11 | ... 2 | 38.5 per cent. |
| September | ... 111 | ... 28=25.2 | per cent. | ... 7 | ... 16 | ... 5 | 52.9 per cent. |
| October | ... 105 | ... 14=13.3 | per cent. | ... 5 | ... 5 | ... 4 | 50 per cent. |
| November | ... 103 | ... 22=21.4 | per cent. | ... 3 | ... 17 | ... 2 | 48 per cent. |
| December | ... 105 | ... 19=18.1 | per cent. | ... 6 | ... 11 | ... 2 | 37.2 per cent. |
| Total | ... 1,237 | ... 227=18.35 | per cent. | ... 72=5.82% | 126=10.2% | 29=2.3% | 62.8 per cent. |
| 1927 | ... 1,157 | ... 8.8 | per cent. | ... 1.8% | 4.8% | 2.1% | 67 per cent |

Well Water, 1928.

| Months. | Well Waters. | Pass. | Condemned. | Suspicious. |
|-------------|--------------|-------|------------|-------------|
| January | ... — | ... | ... | ... |
| February | ... 1 | ... | ... | 1 |
| March | ... 2 | ... | 1 | 1 |
| April | ... 1 | ... | ... | 1 |
| May | ... 2 | ... | 1 | 1 |
| June | ... 2 | ... | 1 | 1 |
| July | ... — | ... | ... | ... |
| August | ... 5 | ... | 4 | 1 |
| September | ... 4 | ... | 3 | 1 |
| October | ... 4 | ... | 2 | 1 |
| November | ... 1 | ... | ... | 1 |
| December | ... 2 | ... | 2 | ... |
| Total | ... 24 | ... 1 | 14 | 9 |
| Grand Total | ... 24 | | | |

